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PREFACE: FUTURE PLANS

This revision takes account of the comments received from the Ocean History Panel in March 1996, who ranked the intitial proposal of December 1995 as number six. It also addresses the priorities established in the ODP Long Range Plan of March 1996. The proposal remains essentially one addressing *Earth's changing climate*, with a component addressing *sealevel change*. All the proposed sites have been re-assessed, and a workable set of drilling priorities established. Dr Jim Kennett, of the University of California, Santa Barbara, has joined the proponents.

However, we have also added two shallow tectonic sites, amounting to one week's drilling, using input from Drs Jean Mascle and Jean-Yves Royer (Villefranche-sur-mer, France), who are now proponents of the updated proposal. These sites are designed to build on the knowledge of continental transform margins gathered on ODP Leg 159 (Côte d'Ivoire), on which Dr Mascle was Co-chief Scientist, and address the *dynamics of the earth's interior*.

More information can be supplied direct to the interested panels later this year, as a great deal of work continues on geophysical data and samples from this region. An initial geophysical data set will be provided to the ODP Data Bank before July 1996. Processing of the 13 600 km of six-channel *Tasmante* seismic data is well underway and should be completed in the third quarter of 1996, substantially improving the seismic data base. In the next few months Dr Tony Crawford (University of Tasmania) will provide definitive petrological input on whether the microgabbros underlying the tectonic sites are related to the transform fault or are older. Other tectonic information will come from fission track and microstructural studies of rocks dredged from the transform fault zone, that are already well underway.

Papers are being written on most aspects of the geology of the area for submission for publication in a Special Volume of the Australian Journal of Earth Sciences in September 1996, and these include geophysical interpretation, tectonics, petrography and geochemistry of igneous and sedimentary rocks, and isotope and biostratigraphic studies of Quaternary sediment cores.

It is clear that all this work can further strengthen the proposal, and we intend to make another revision on the basis of the recommendations and decisions of ODP in time for the December 1996 cutoff.

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1. ABSTRACT

The area between Australia's southernmost prolongation (Tasmania and the South Tasman Rise) and Antarctica is a key to understanding global Cainozoic changes in climate and current patterns, caused by the drifting of Australia northward from Antarctica. This relatively shallow region is one of the few where complete Cainozoic carbonate-rich sequences can be obtained in present-day latitudes of 40-50°S, and palaeo-latitudes of up to 70°S. It is also one where basic questions, related to the nature of transform margins, can be addressed. There is a rich data base, with numerous seismic profiles, all proposed sites swath-mapped, DSDP sites, and numerous dredge and core locations.

The total proposed program of six holes is for 4145 m of core in water depths of 2500-3570 m. It includes four high-resolution *palaeoceanographic* sites to cover Cretaceous-Tertiary boundary changes, the Palaeogene rifting phase, the Oligocene breakthrough of the Circum-Antarctic current, and Neogene climatic variations preserved in calcareous oozes. These sites will deal with latitudinal variations in water masses in high southern latitudes, and longitudinal differences caused by the existence of a shallow ridge between the Indian and Pacific Oceans through into the Miocene. This proposal is complementary to two highly ranked ODP palaeoceanographic proposals: 367 in the Great Australian Bight to the northwest, and 441 east of New Zealand.

We also propose the drilling of two shallow *tectonic* sites on the continental part of the Tasman Fracture Zone (western margin of the South Tasman Rise), to examine thermal history, deformation, uplift and subsidence, as well as the effects of magmatic intrusion along a transform margin. This would be complementary to ODP Leg 159, on the Côte d'Ivoire transform margin, and would help extend the global model for transform margins that involves both continent-continent and continent-ocean motion. New information would relate to the intrusion mechanism of a basic body within the transform margin.

Of the total *palaeoceanographic* program, three holes deal with the Indian Ocean at varying latitudes: one concentrating on the Neogene sequence, and two on the Palaeogene sequence as well; two are planned to reach the Cretaceous-Tertiary boundary. One hole deals with the Pacific Ocean, covering the Neogene and some of the Palaeogene sequence. Three alternate sites have also been selected.

The early Palaeogene sequence (Paleocene to middle Eocene) is different in the north and south, although probably consisting of shallow marine deltaic mudstone in both areas. In the north it is gray and contains abundant organic matter and calcareous temperate fossils; but in the south it is green and contains siliceous organisms of glacial character, and some varves. In places it is organic-rich and it is possible that, in the western sites located in the initial rifts, anoxic sediments formed in barred basins.

The late Paleogene open ocean carbonate sequence (late Eocene to early Oligocene) is of considerable importance because this was a key time in the development of the seaway. Sites on either side of the South Tasman Rise should have distinctive Indian Ocean and Pacific Ocean characters.

The mid-Oligocene unconformity will be penetrated in all holes, and the minimum age gap bracketing the unconformity will allow more accurate dating of the initial breakthrough of the Circum-Antarctic Current in the "southern gateway" south of Australia. The nature of the immediately overlying sequences (age, grainsize, composition) will show similarities and differences in current effects in different locations.

The Neogene sequence, largely oozes and chalk, will help document the deepening of the ocean after Oligocene breakup of Antarctica and Australia, Australia's drift northward through climatic zones, the general fluctuations of sea temperatures and oceanic fronts as Quaternary glaciation became a dominant climatic effect, rapid temperature changes, and the change to similar fossil assemblages on either side of the barrier with time.

2. GEOLOGICAL SETTING

The Tasmanian offshore region consists of continental crust of the Tasmanian margin, the South Tasman Rise and the East Tasman Plateau, and is bounded on all sides by oceanic abyssal plains (Fig. 1). The oceanic crust to the east is believed to have formed by the seafloor spreading that formed the Tasman Sea in the Late Cretaceous and Early Tertiary. That to the south and west is believed to have formed in the Cainozoic, and perhaps the latest Cretaceous, by the seafloor spreading that led to the separation of Australia and Antarctica.

The continental shelf around Tasmania (Fig. 2) is generally less than 50 km wide and much of it is non-depositional at present. The continental slope west of Tasmania is about 100 km wide, and falls fairly regularly from water depths of 200 m to 4000 m. The continental rise lies at 4000-4500 m, and beyond that is the abyssal plain, generally 4500-5000 m deep. The Sorell Basin (Fig. 1) west of Tasmania is a southward prolongation of the gas-producing Otway Basin and is prospective for hydrocarbons. Sampling cruises have shown that the major 320°-trending scarp in deep water southwest of Tasmania is of continental origin, and that Upper Cretaceous and Palaeogene shallow marine sandstone, siltstone and mudstone are widespread in deep water west of Tasmania, overlain by Neogene pelagic carbonates. High grade Palaeozoic metamorphic rocks and granitoids have been dredged from the basement.

The South Tasman Rise (STR) is a large, NW-trending bathymetric high that rises to less than 1000 m below sea level, and is separated from Tasmania by a WNW-trending saddle more than 3000 m deep (Fig. 2). DSDP Site 281 showed that the STR has a continental core, drilling Palaeozoic quartz-mica schist (Kennett, Houtz et al., 1975). The overlying sequences in faulted basins are known to contain Neogene pelagic carbonates and Palaeogene marine mudstones, and seismic evidence suggests they also contain Cretaceous sediments. The top of the rise is a gentle dome with low slopes, but slopes between 2000 and 4000 m on its eastern and southern sides are greater. The western slope is not great to 3000 m, but below that there is a very steep scarp trending 350° and dropping away to 4500 m, part of the Tasman Fracture Zone.

Sampling of the western scarp, part of a western terrane of the South Tasman Rise, has recovered Palaeozoic basement rocks including garnet-bearing schist, gneiss, granodiorite and pegmatite, and younger basic intrusive and extrusive rocks. Sampling of an eastern

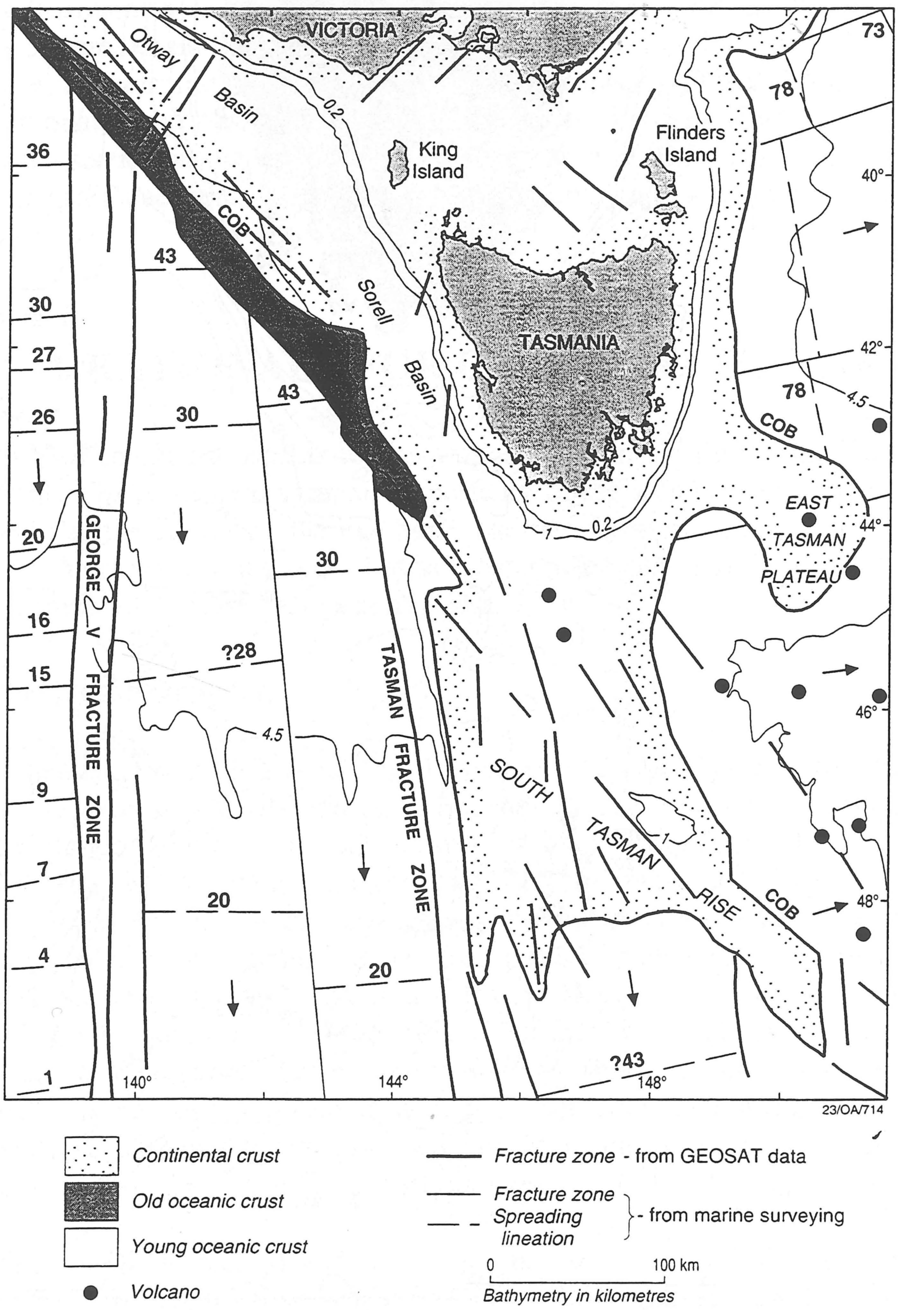


Figure 1. The tectonic elements of the offshore Tasmanian region. The position and ages (Ma) are taken from CCPEMR (1991). COB = edge of coherent continental crust. "Old oceanic crust" may be of Early Cretaceous age. "Young oceanic crust" is of Late Cretaceous age east of Tasmania/STR, and of Cainozoic age south and west of Tasmania/STR.

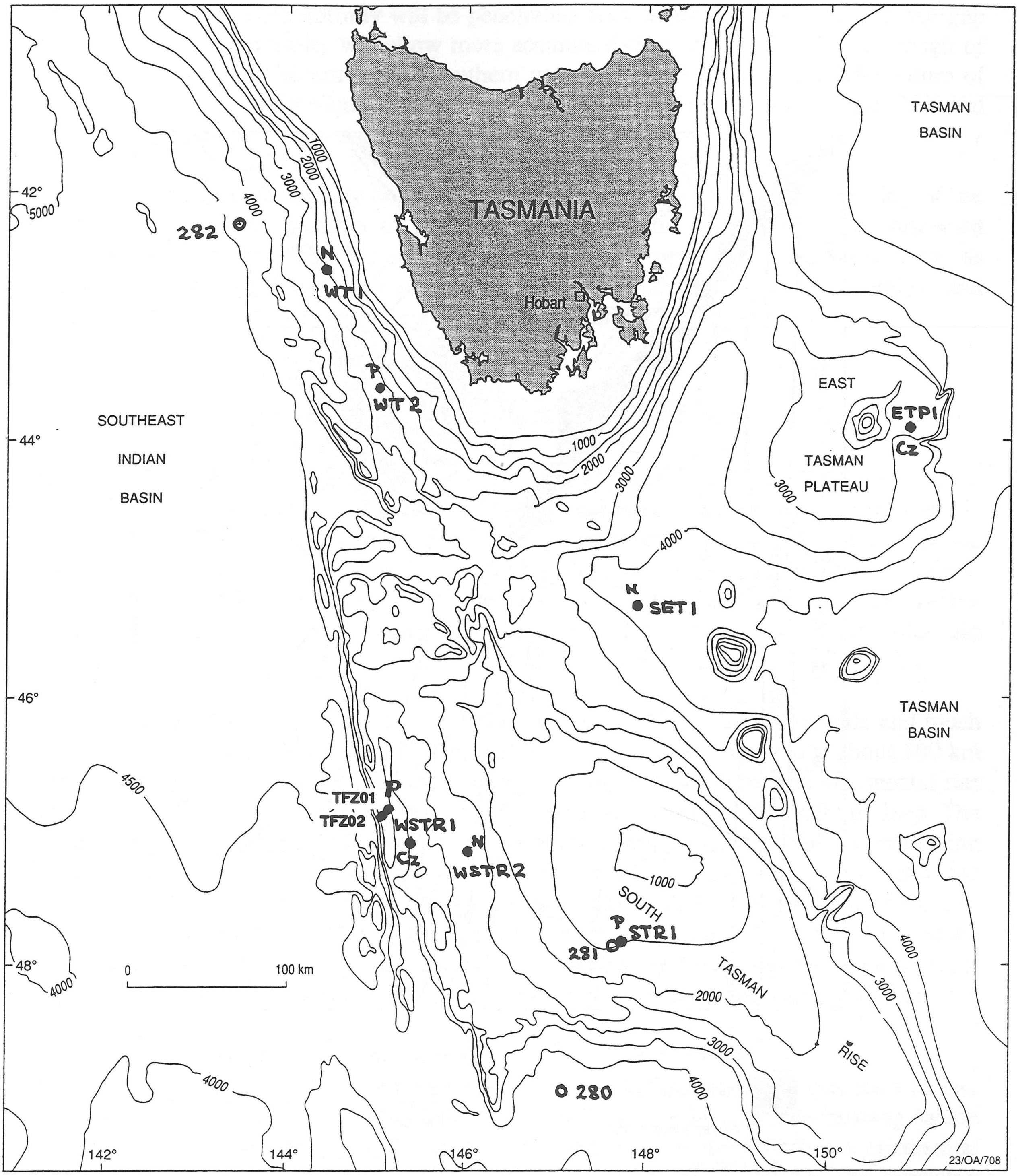


Figure 2. Bathymetry of the offshore Tasmanian region, making use of *Tasmante* Cruise swath-bathymetry. DSDP Sites are shown as open circles and proposed ODP sites as closed circles. Predominantly Neogene sites = N; predominantly Palaeogene sites = P; total Cainozoic sites = Cz.

terrane (east of a north-south fracture zone at 146° 15'S) showed it to consist of greenschist to amphibolite-facies basement rocks, including acid plutonics.

The East Tasman Plateau is a nearly circular feature, 2500-3000 m deep, separated from southeast Tasmania by a saddle 3200 m deep (Fig. 2). Slopes are generally low, but they are considerably greater on the plateau's flanks. Atop the plateau is the Soela Seamount guyot, that formed as the result of Palaeogene hotspot volcanism and has yielded Eocene shallow-water carbonates and basalt. The plateau has up to 1.5 seconds two-way time (twt) of sedimentary section in places, believed to be entirely of Cainozoic age: Neogene pelagic carbonates and Palaeogene mudstones. It is underlain by high-pressure continental basement rocks.

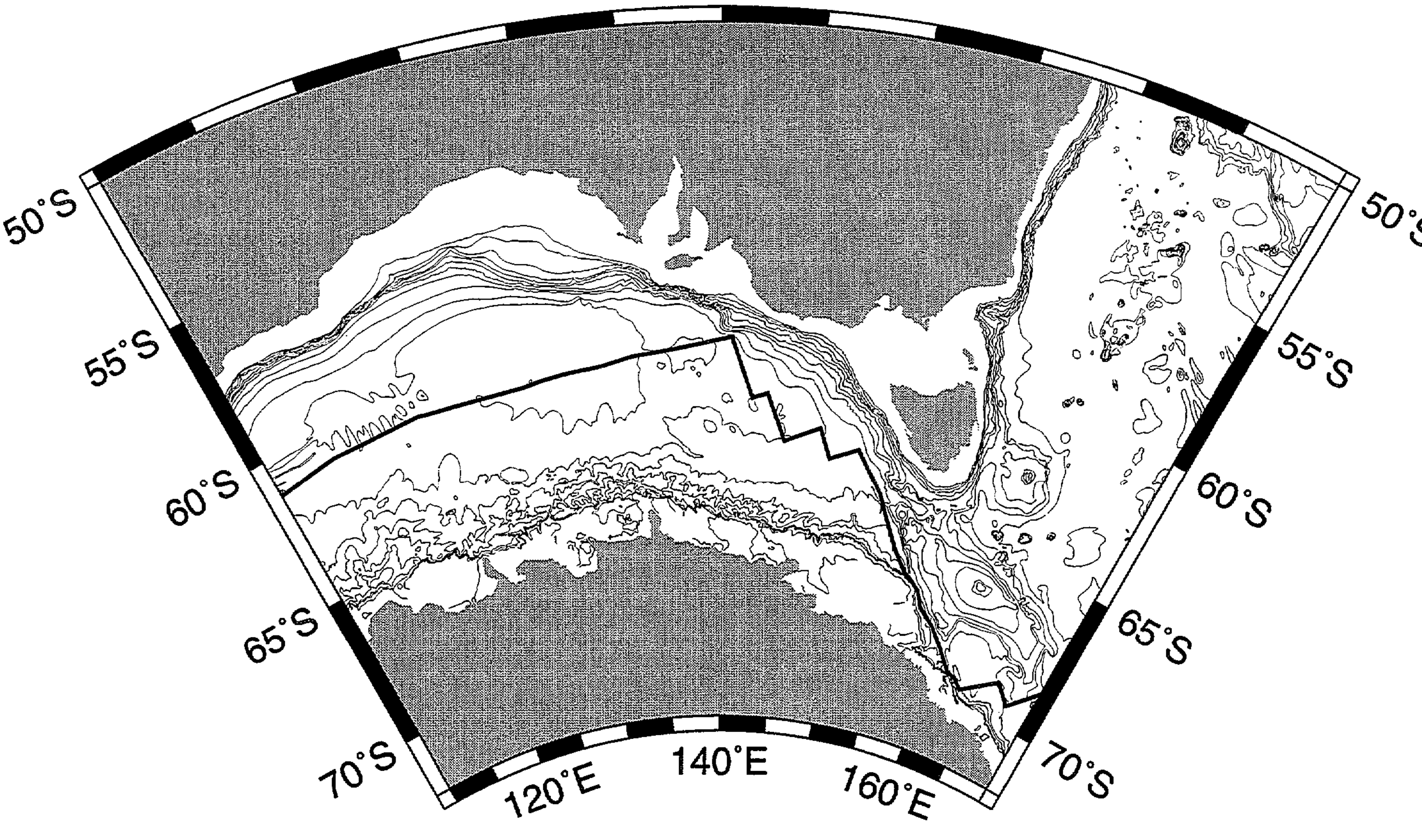
3. RATIONALE FOR CHOOSING THIS AREA

There are two important aspects to the proposed drilling in this area: palaeoceanographic and tectonic. The palaeoceanographic importance of the area lies in its location between the Indian and Pacific Oceans on the one hand, and the Australian and Antarctic continents on the other. The tectonic importance lies in its character as a transform margin that was the last connection between Antarctica and Australia.

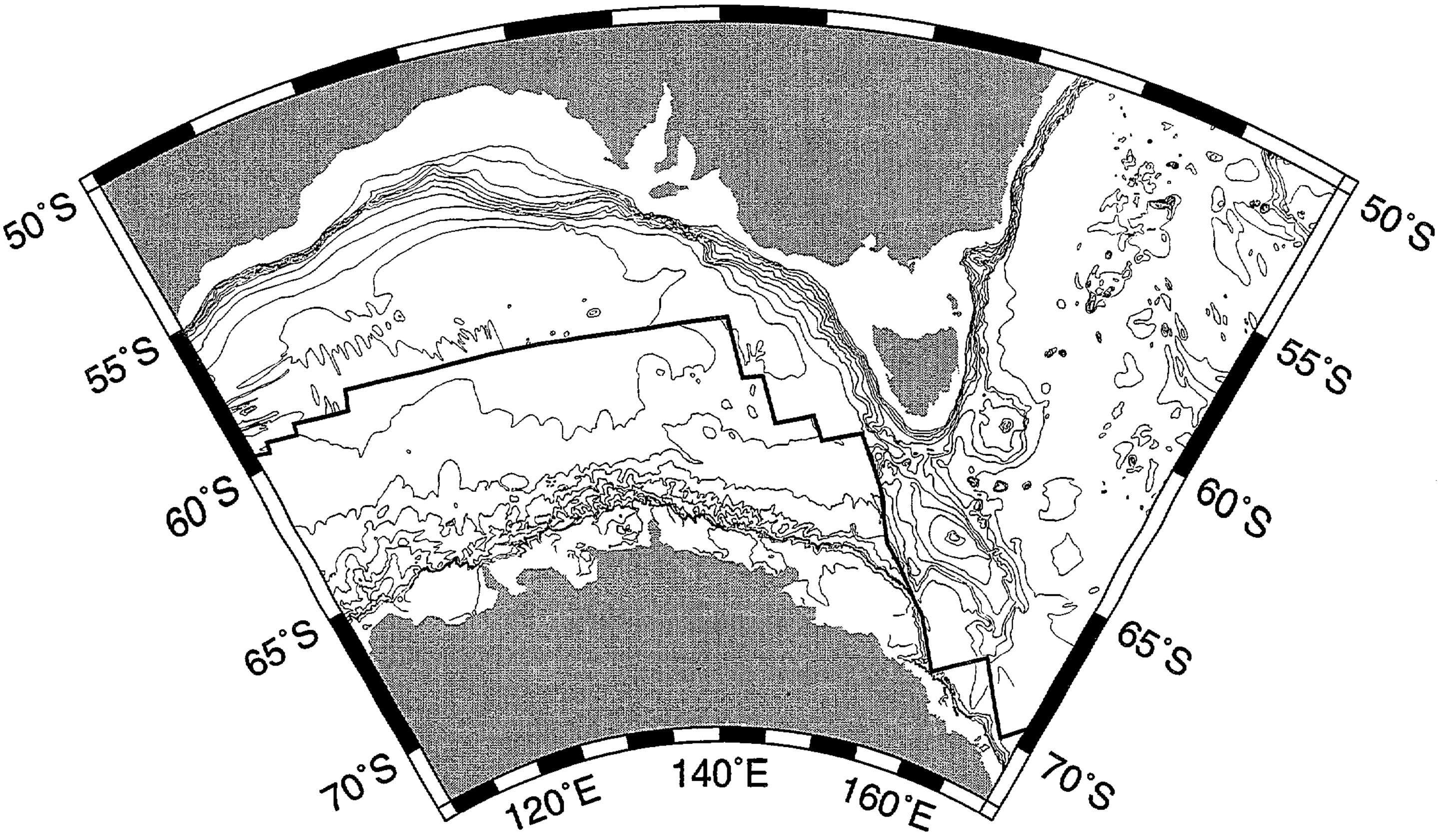
3.1 Palaeoceanography

The continental area south and west of Tasmania is of *global palaeoclimatic significance.* It is the best place to study the effects of Eocene-Oligocene Australia-Antarctic breakup on the global pattern of currents, both because of its geographic position, and because the water was shallow and hence calcareous fossils are preserved. Figure 3A shows how Australia and Antarctica were locked together in the late Eocene, preventing circum-Antarctic circulation. At that time, and earlier in the Palaeogene, the water masses on either side of the barrier between the Indian and Pacific Oceans were distinctly different. This is clearly an excellent place to study the initiation of the Circum-Antarctic Current in the mid-Oligocene, when the barrier was no longer effective (Fig. 3B), and the increasing similarity of the water masses on either side of the barrier thereafter. Its position means that it is also an excellent place to study Cainozoic Southern Ocean climatic variations, and especially the movements north and south of key climatic zones.

A number of first-order questions about the response of the climate system on "Milankovitch" or orbital time scales have been answered for the late Quaternary. The Southern Ocean participation in the glaciation cycles of the past 500,000 years appears to track well-known Northern Hemisphere indicators of cryospheric, atmospheric, and oceanographic variability (Imbrie et al., 1992; Imbrie et al., 1993). The Southern Ocean paleoceanographic record, manifested in its thermal response (Howard and Prell, 1992) and carbon cycling (Howard & Prell, 1994; Oppo et al., 1990) mirrors that of the Northern Hemisphere, though there appears to be a lead in the Southern Ocean (Howard and Prell, 1992; Howard and Prell, 1994). Similarly, the Southern Ocean's deep-water chemistry appears to show a sharp response to the inception of Northern Hemisphere ice sheet growth and its effects on the North Atlantic (Hodell & Venz, 1992).



Chron 18 ~ 40 Ma



Chron 13 ~ 34 Ma

Figure 3. Palaeogeographic reconstructions, using present bathymetric contours from the GEBCO charts for Chron 18 and Chron 13. Breakthrough of the Circum-Antarctic Current occurred at about Chron 13. Rotations after Royer & Sandwell (1989). Cande & Kent (1995) reversal time scale.

Despite the excellent documentation of Southern Ocean palaeoclimate in the upper part of the Pleistocene, where 100,000-year cycles dominate variability, no sections have been drilled to address how this part of the world ocean saw the mid-Pleistocene transition from obliquity-dominated cycles (41,000-year periodicity) to eccentricity-dominated cycles (Ruddiman et al., 1989). The only Southern Ocean section that recovered this "transitional" period had poor recovery through it (Hodell & Venz, 1992), so this important climatic transient in global climate remains poorly documented in the Southern Ocean.

In addition, the early Pliocene warming, now known from the Northern Hemisphere, has not been quantified from Southern Ocean palaeoceanographic records.

The Cretaceous and Cainozoic sedimentary record of the region is strongly influenced by the history of the breakup of Australia and Antarctica, from the continental stretching of the Cretaceous through to the fast-spreading phase of the last 45 million years. This record starts with early-rift non-marine sedimentation in the Early Cretaceous, continues with restricted shallow-marine sedimentation in the rifts between the two continents in the Late Cretaceous and early Palaeogene, and changes to more open marine sedimentation in the late Palaeogene. The Oligocene record will show details of how the Circum-Antarctic Current first came into play through the formerly closed gateway south of Australia, as Antarctica cleared the South Tasman Rise and a distinctive unconformity was formed.

In 1973, Site 281 of DSDP Leg 29 in this region permitted the documentation of a broad, globally significant history of the Cainozoic events in the region. Shackleton & Kennett (1975) produced composite oxygen and carbon isotope curves from foraminifera that covered the Late Paleocene to the Pleistocene from Sites 277, 279 and 281. These show the now classical general fall of bottom and surface water temperatures through the Cainozoic, with a general fall in the Palaeogene, a rapid fall in the early Oligocene, steady temperatures until the middle Miocene when there was another rapid fall as Antarctic glaciation came into full sway, and then the complex fluctuating fall through into the Pleistocene. For Site 281 (STR), the sequence studied isotopically was the early Miocene to the Pliocene, although the hole bottomed in the late Eocene. In contrast, in Site 277 (Campbell Plateau) the earliest Miocene to Late Paleocene was covered. The authors believed their sampling interval was less than 1 m.y.

The Leg 29 sites were generally located on regional highs in order to minimise the depth of penetration necessary to reach older strata, and hence much of the sequence was cut out by hiatuses. Furthermore, this first scientific drilling in the area usually was carried out with only occasional cores in the holes, so that detailed resolution of the sediment history was impossible. Our proposal, for continuous coring down to the oldest open marine sequences (Eocene) in this critically important area, would allow a detailed stable isotope stratigraphy to be generated, of global significance. The oldest such sequence would lie barely 600 m below sea floor, and hence should not suffer from serious diagenetic problems.

The thickness of all the sequences will allow high-resolution biostratigraphy and isotope stratigraphy: more than 1500 m of Late Cretaceous, 2500 m of Palaeogene, and 600 m of Neogene strata are present in places. Much of the Neogene sequence should be drillable with the advanced piston corer, so one could expect excellent recovery and little disturbance. The older sequences would require the use of the extended core barrel or the rotary core barrel.

3.2 Tectonics of the South Tasman Rise/Antarctic transform margin

The most recent hypotheses (Exon, Hill & Royer, 1995; Exon, Royer & Hill, 1996, and Rollet et al., in press) suggest that the Tasmanian region has been subjected to *three phases of stretching and breakup*, as part of the dispersion of East Gondwana (Table 1 & Fig. 4). All tectonic phases are addressed indirectly by this proposal, but the last phase, that of the final breakup between STR and Antarctica, is directly addressed by targets on the Tasman Fracture Zone (TFZ: the western marginal ridge of the STR).

Stretching between Australia and Antarctica was in a NW-SE direction from 160 to 95 Ma (Willcox & Stagg, 1990; Fig. 4A). Whether slow speading occurred in a NW-SE direction from 95 to 56 Ma, as postulated for example by Cande & Mutter (1982), is not conclusively proven by magnetic anomalies. We consider it more likely that there was a break in Australia-Antarctica movement while the Lord Howe Rise (LHR: to the east), moved away to the ENE from Australia-Antarctica to form the Tasman Sea, by stretching from 95 Ma perhaps, and by spreading from 80 to 50 Ma (chrons 33-22; e.g. Weissel & Hayes, 1977; Fig. 4B). There has been fast N-S spreading from 50 Ma to the present day (chron 22 onwards; Weissel & Hayes, 1972)

Table 1: Development of the Tasmanian Transform Margins

Location	Occurrence	Time	Ma
Tasmania/Southern Australia/Antarctica	Early rifting and transform motion: NW-SE	M. Jurassic to E. Cenomanian	160-95
	? Slow spreading: NW-SE or N-S	?	?
	Passive margin, spreading (22-1): N-S	E. Eocene onward	50-0
Tasmania/STR/LHR	Early rifting: ENE-WSW	E. Cenomanian to Santonian	95-80
	Passive margin, spreading (33-22): ENE-WSW	Campanian to E. Eocene	80-50
	Passive margin & no spreading	E. Eocene onward	50-0
STR/Antarctica	Early rifting: N-S	?E. Eocene	?50-43
	Intracontinental transform faulting to W, spreading to S of STR (18-8): N-S	E. Eocene to L. Oligocene	43-28
	Continent-ocean transform to W, spreading (8-6): N-S	L.Oligocene to E. Miocene	28-20
	Passive margin, spreading to S (6-1): N-S	Miocene onward	20-0

The tectonics of the Tasmanian region have been discussed recently by Exon, Hill & Royer (1995), Exon, Royer & Hill (1996), and Rollet et al. (in press). The early NW-SE strike slip motion (Fig. 4A) chiefly affected the west Tasmanian margin and the eastern STR. The later ENE stretching motion (Fig. 4B) affected eastern Tasmania and eastern STR, by thinning the crust as the LHR, and for a time the ETP, moved away. The final N-S motion affected

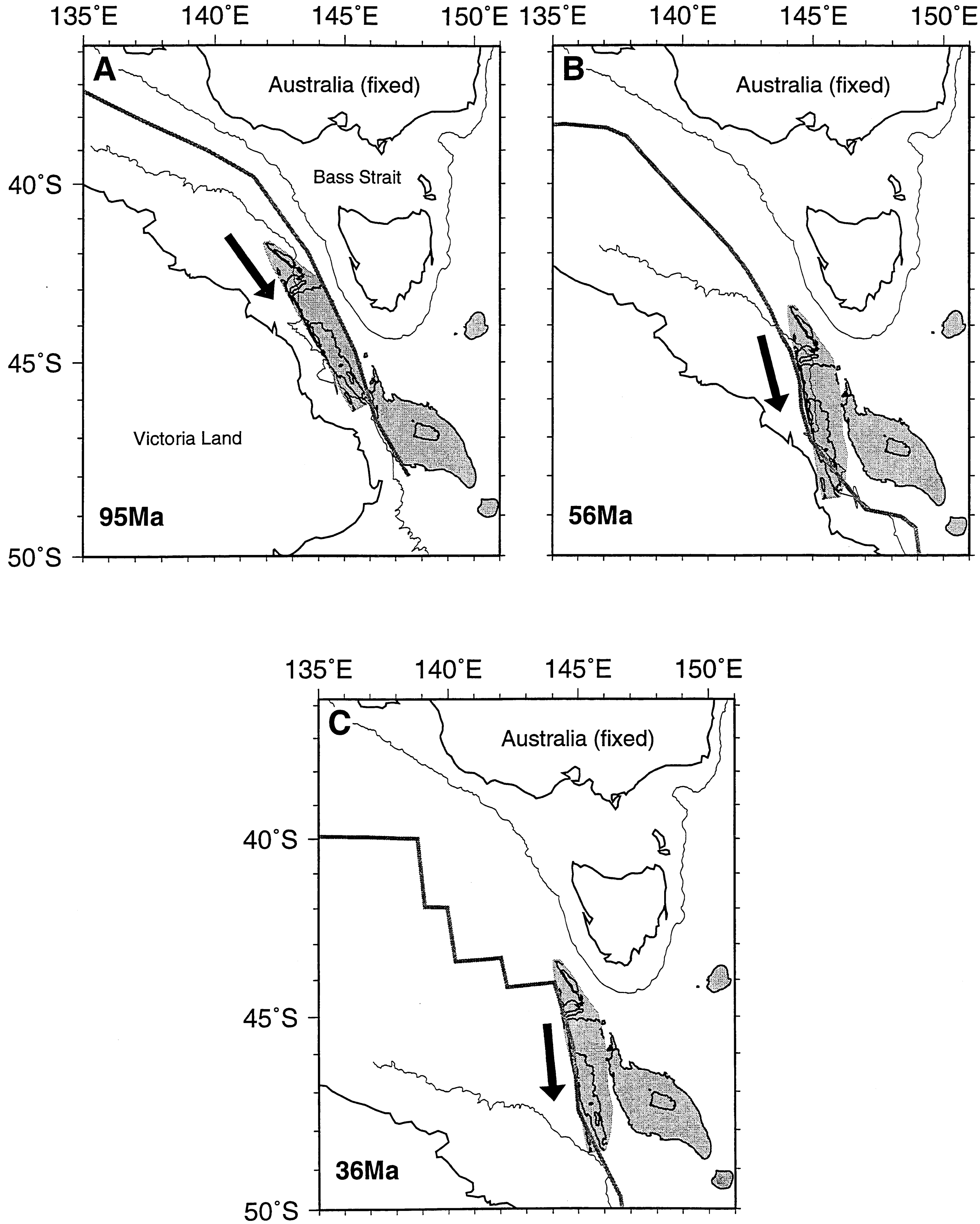


Figure 4. Tectonic reconstructions of East Gondwanan dispersal at three key times: A) mid Cretaceous (95 Ma) after NW-SE stretching between Australia and Antarctica; B) early Eocene (56 Ma) after WSW-ENE spreading between Australia and the Lord Howe Rise; C) early Oligocene (36 Ma) during N-S spreading between Australia and Antarctica, and at about the time of clearance of Antarctica and the South Tasman Rise.

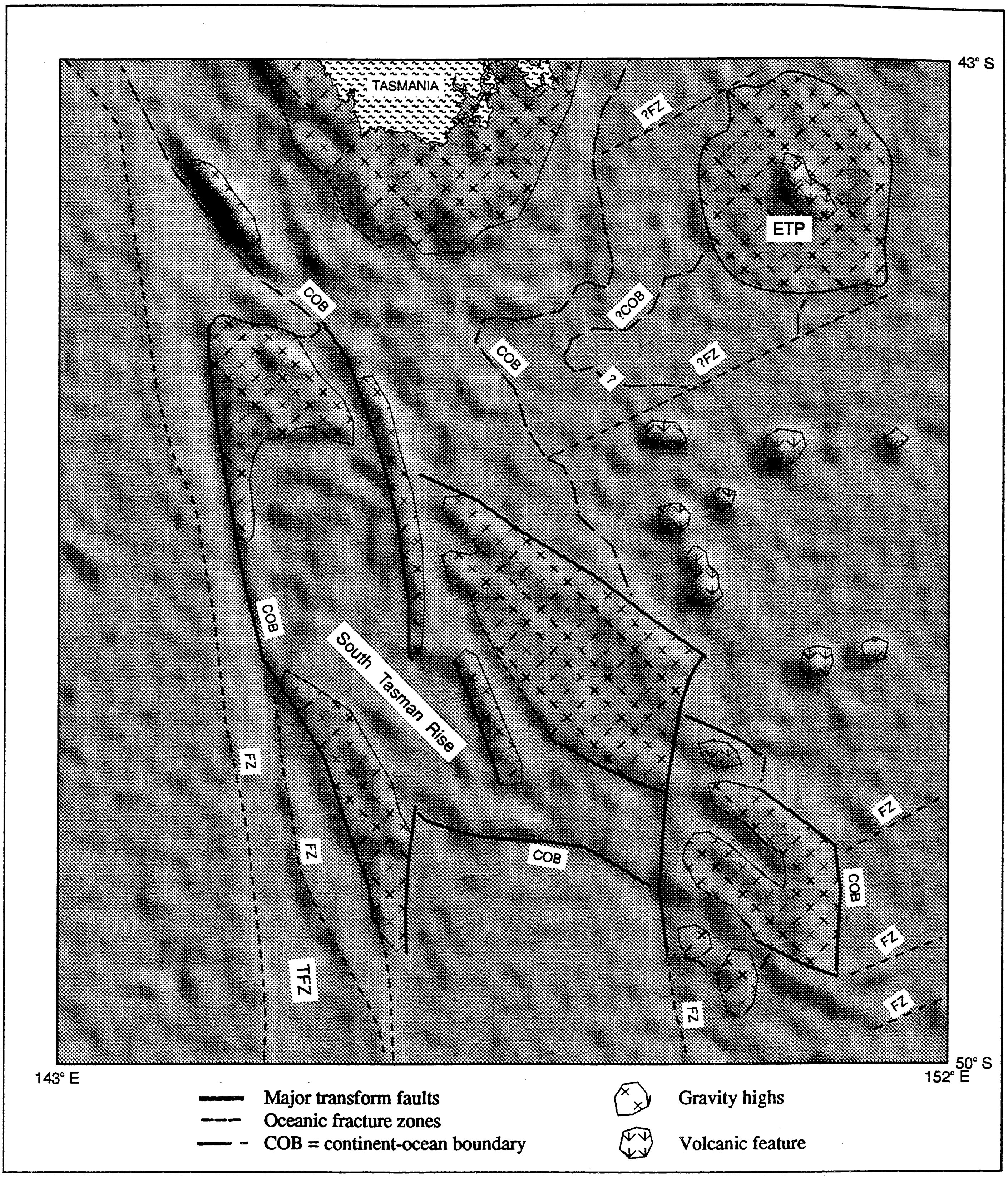


Figure 5. Map of satellite gravity data, showing the major interpreted tectonic features of the area south of Tasmania. The first period of tectonism is represented by the NW trending transform faults, the second by the ENE trending fracture zones, and the third by the N-S trending transform faults and fracture zones.

the west Tasmanian margin, and strongly reshaped the STR, and especially the western margin (transform motion) and southern margin (normal faulting). The STR finally separated from Antarctica at about 36 Ma (Fig. 4C).

The STR is cut into two major continental terranes by a N-S transform fault zone at 146°15'E (Fig. 5). The western terrane is characterised by rotated basement blocks and intervening basins mostly trending 270-290°. The eastern terrane is characterised by basement blocks and intervening strike-slip basins trending 300-340°. Rollet et al. (in press) hypothesise that the western STR terrane was attached to Antarctica during the early movement, and moved down the west coast of Tasmania along a 320° shear zone, forming the landward-dipping continental blocks along the present continent-ocean boundary. The eastern terrane either moved with the western terrane, or was probably welded to it along the 146°15'E fracture zone in the early Tertiary.

The STR is bounded to the west by the TFZ extending south to Antarctica (Figs. 1 & 5). Adjacent to the STR, the TFZ is represented by a straight to sinuous scarp 500 km long and up to 2000 m high, with slopes of 15-20° to the west. It also forms a ridge rising hundreds of metres above the sediments to the east. Dredging has shown the scarp to consist of continental fault-blocks dipping landward. Beyond the scarp to the west is a string of sheared parallel highs, and beyond that is lightly sedimented Oligocene oceanic crust (Fig. 1) 4200-4600 m deep, with a distinct E-W spreading fabric. Seismic sections at the proposed sites TFZ01/02 suggest that the ridge consists of deformed sediments that are apparently of Palaeogene and Cretaceous age. Dredging has recovered Palaeogene sediments, and underlying microgabbros that may have been intrusive bodies emplaced during transtensional transform motion.

The comparison between the TFZ sites, and those drilled on ODP Leg 159 on the transform margin off the Côte d'Ivoire (Mascle, Lohmann, Clift et al., 1996), should further refine the global model for transform margin development. Although having a generally similar setting to Leg 159 sites, the TFZ sites suggested here will overlie and drill a basic intrusion that will have added heat and magmatic fluids to the construction of the margin. Such intrusions were not found off the Côte d'Ivoire.

3.3 Conclusions

The need for ODP drilling as outlined above is compelling, and there is no alternative way to acquire the necessary information. Everything has now been done to address the global palaeoclimatic and plate tectonic questions in other ways, and a very extensive data set, including DSDP drilling, has helped greatly in preparing this proposal. An extensive gravity coring and dredging campaign has provided ground truthing for about 20 000 km of good-quality seismic profiles. The seismic grid includes 13 600 km of moderately high-resolution data recorded along with 200 000 km^2 of swath bathymetry and imagery by R.V. *L'Atalante* in 1994, and we believe that appropriate and safe sites can be selected on the basis of existing data. The six sites proposed would be in water depths of 2500-3570 m, so calcareous organisms should be well preserved, allowing detailed isotope studies to be carried out.

4. EXISTING SURVEYS AND DATA SETS

4.1. Dredges, cores and reflection seismic data

The west Tasmanian margin and the South Tasman Rise have been the subject of a number of BMR/AGSO cruises over the years:

- BMR Continental Margins high-energy sparker seismic survey - 1972
- BMR low-energy sparker seismic survey of continental shelf - 1973
- BMR Cruise 40 Bass Basin contract seismic survey - 1982
- *Sonne* SO-36B & C cooperative seismic and sampling surveys - 1985
- BMR Cruise 67 *Rig Seismic* sampling survey - 1987
- BMR Cruise 78 *Rig Seismic* seismic and sampling survey - 1988
- AGSO Cruise 125 *L'Atalante* swath-mapping and seismic survey - 1994
- AGSO Cruise 147 *Rig Seismic* sampling survey - 1995

A total of 167 successful dredges and 81 successful cores have been taken by a variety of institutions in the region (Table 2 & Fig. 6).

Table 2: Successful bottom sampling off Tasmania

Source	Cores	Dredges	Grabs
US institutions	39	1	2
Sonne 36	43	13	
BMR 67	18	3	
BMR 78	42	10	8
AGSO 147	25	54	9
Total	**167**	**81**	**19**

A great deal of seismic and sedimentological information for the area between Australia and Antarctica, arising from cruises of R.V. *Vema*, R.V. *Robert D. Conrad* and USNS *Eltanin*, is presented in a synthesis volume edited by Hayes (1971). The basic data for five papers discussing the sediments of the southeast Indian Ocean come from a collection of about 300 cores taken on a number of cruises carried out in a very methodical manner. Conolly (1971) has written a brief and useful overview of the results, and he outlines the physiography, the sediment thickness above basement, and the distribution of surface sediment types. The cores taken by R.V. *Eltanin* in the region between 1966 and 1967 were interpreted by Watkins & Kennett (1971). All US core information is available through the Core Curators file of the US National Geophysical Data Center, and that was presented in Appendix 3 of Exon (1995).

In 1973, BMR recorded the first methodical regional seismic survey as far south as 46°S, using a 120 kilojoule sparker source, a six-channel streamer, a generally east-west orientation, and a line spacing of about 35 km. In addition, there is a sizeable semi-detailed company data set on the continental shelf of west Tasmania, most of it listed by Moore et al. (1991).

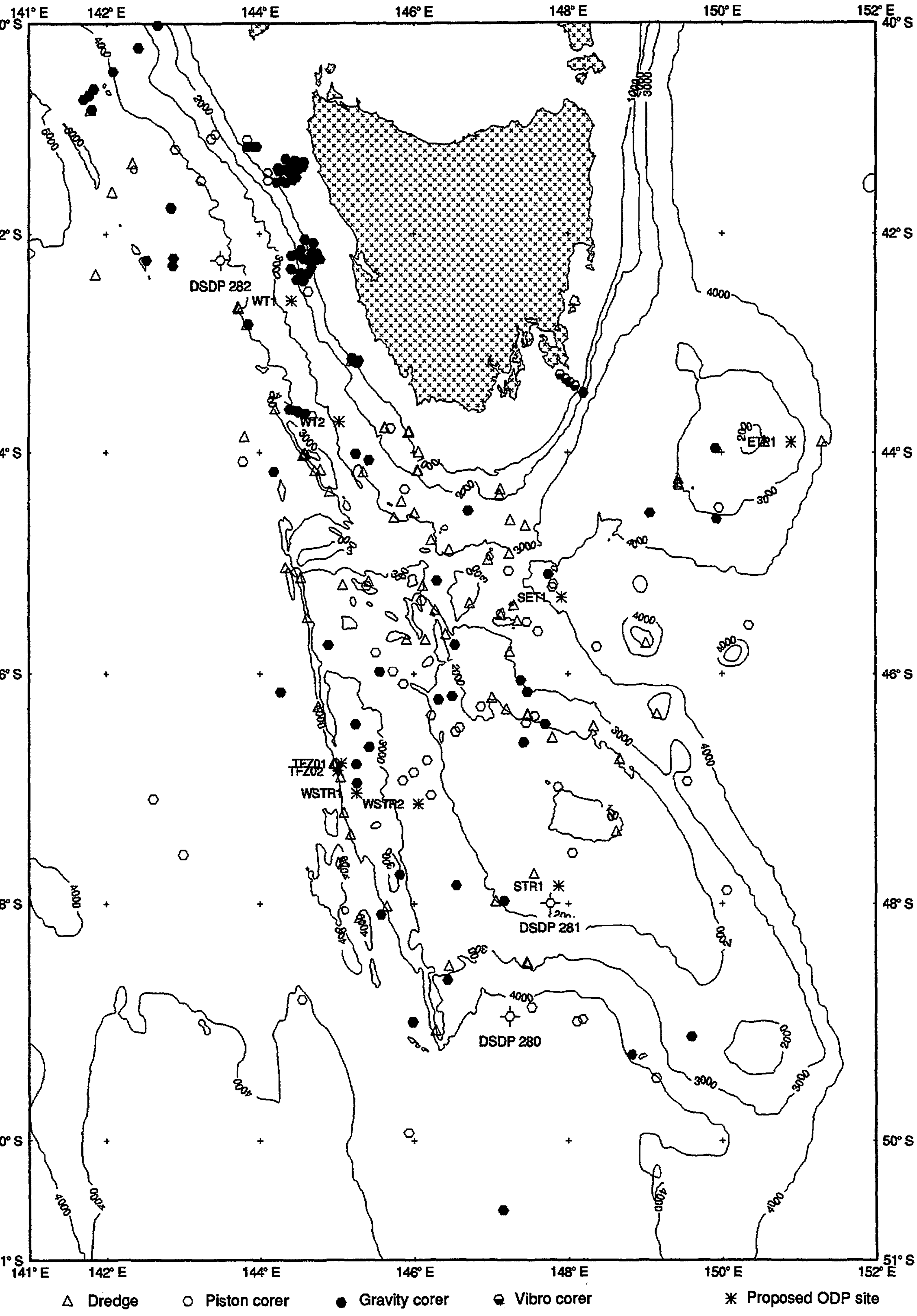


Figure 6. Map relating all relevant sampling locations off Tasmania, including DSDP sites, to bathymetry in metres.

The distribution of good-quality open file seismic data in the region is shown in Figures 7 & 8. The major data set is the *Tasmante* grid of 13 600 km of six-channel high-resolution data, most of it in parallel tracks 15 to 20 km apart, trending NNW. Another important data set is the 3820 km of *Sonne* data recorded using an air gun array of 25.6 litres, and a 24 channel, 2400 m seismic cable, mostly with a northeast to southwest orientation, and shot in 1985. In 1973, Shell's *Petrel* recorded 600 km of similar data off west Tasmania with a zigzag orientation of northeast or southeast. In 1988, *Rig Seismic* recorded 1750 km of seismic data as part of BMR Cruise 78 off west Tasmania, using an airgun array of 1600 cubic inches, and a 48-channel cable, 1200 m long.

4.2. Deep Sea Drilling Project (DSDP)

In 1973, Leg 29 of the Deep Sea Drilling Project (DSDP) drilled four partly cored holes in the Tasmanian region (Kennett, Houtz et al., 1973, 1975A) using the *Glomar Challenger* (Fig. 2 & Table 3).

Table 3: Deep Sea Drilling Project (DSDP) Sites off Tasmania

Site	Lat (S) Long (E)	Water depth (m)	Penet-ration (m)	Total recovery *	Maximum age of sediments	Basement type
280	48° 57.44' 147° 14.08'	4176	524	19%	Early to mid Eocene	Intrusive basalt
281	47° 59.84' 147° 45.85'	1591	169	62%	Late Eocene	Late Carboniferous Palaeozoic schist
282	42° 14.76' 143° 29.18'	4202	310	20%	Late Eocene	Pillow basalt
283	43° 54.60' 154° 16.96'	4729	592	10%	Paleocene	Altered basalt

Reference: Kennett, J.P., Houtz, R.E. et al. (1975A)
** Total recovery = core recovered divided by depth of maximum penetration*

Site 282 was drilled to 310 m and lies deep on the west Tasmanian margin, 160 km west of Cape Sorell on *Sonne* line 36B-46, which shows it to have been on a basement high. The sequences drilled in it include much of the Cainozoic, but contain four major unconformities. It contains 240 m of late Eocene to middle Oligocene sediments, resting on a basalt flow of presumed Tertiary age. The basal, late Eocene unit is 103 m thick. It consists of a glassy and zeolitic mudstone laid down in reducing conditions, with appreciable organic carbon and hydrocarbons, but contains shallow-water benthic forams at some levels, as well as shallow water coccoliths and sponge spicules. Thus the conclusion of Kennett, Houtz et al. (1975A), that the sequence was laid down in deep water, remains in doubt.

The conformably overlying early to mid Oligocene sediments are olive grey mudstones and are 78 m thick. They contain nannofossils, sponge spicules and glauconite stringers. The next unit up is a dark olive grey, organic carbon bearing, nannofossil-rich mudstone, 9 m thick. It contains shelly fossils and a possibly shallow-water benthic foram assemblage. The uppermost middle Oligocene unit is 50 m of grey, glauconite and micronodule bearing, quartz rich mudstone, rich in nannofossils and sponge spicules, and containing a shallow-

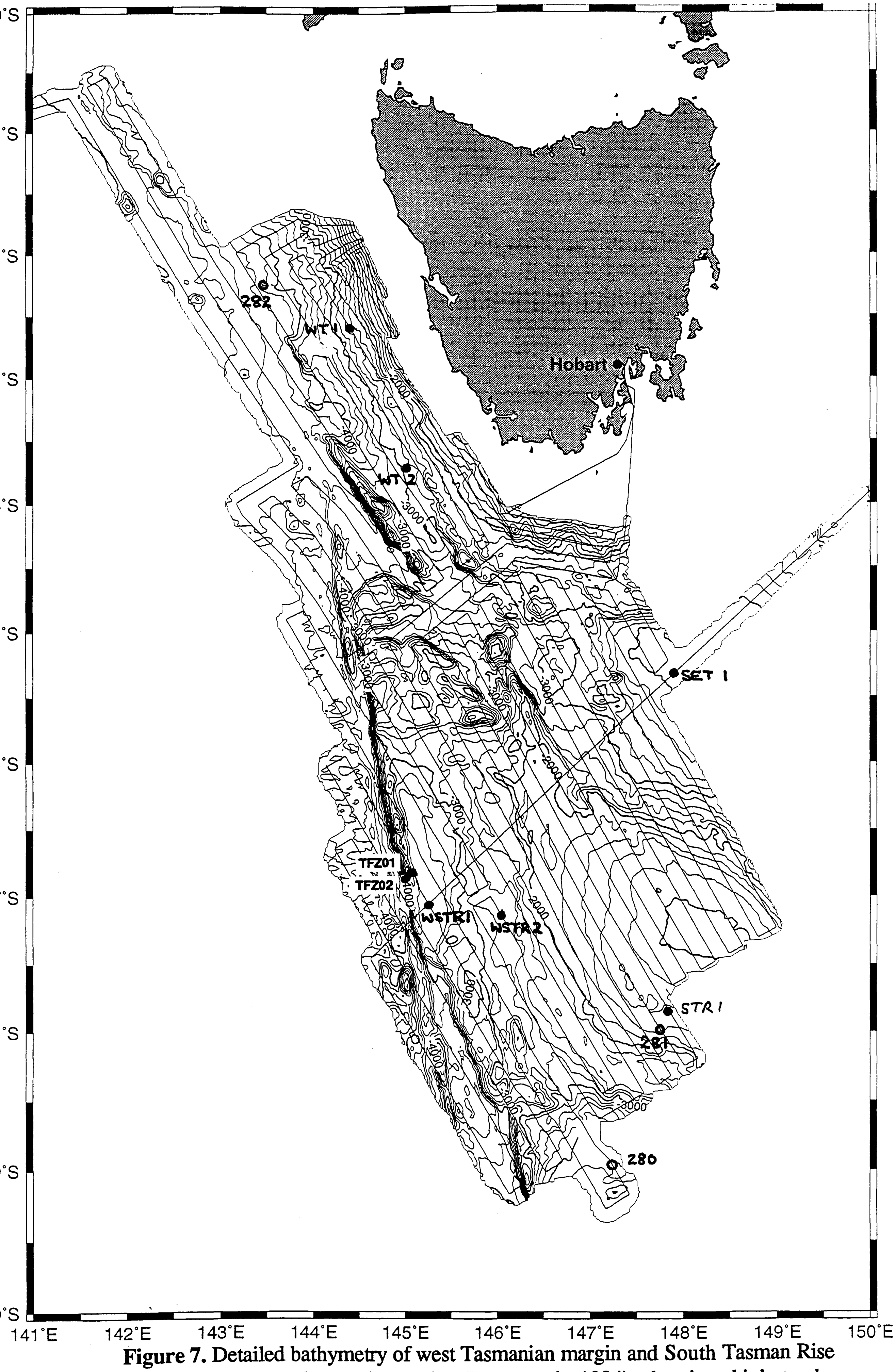


Figure 7. Detailed bathymetry of west Tasmanian margin and South Tasman Rise from *Tasmante* swath-mapping cruise (Exon et al., 1994), showing ship's tracks and locations of DSDP Sites and proposed ODP sites. Six-channel seismic data were acquired along the 13 600 km of tracks.

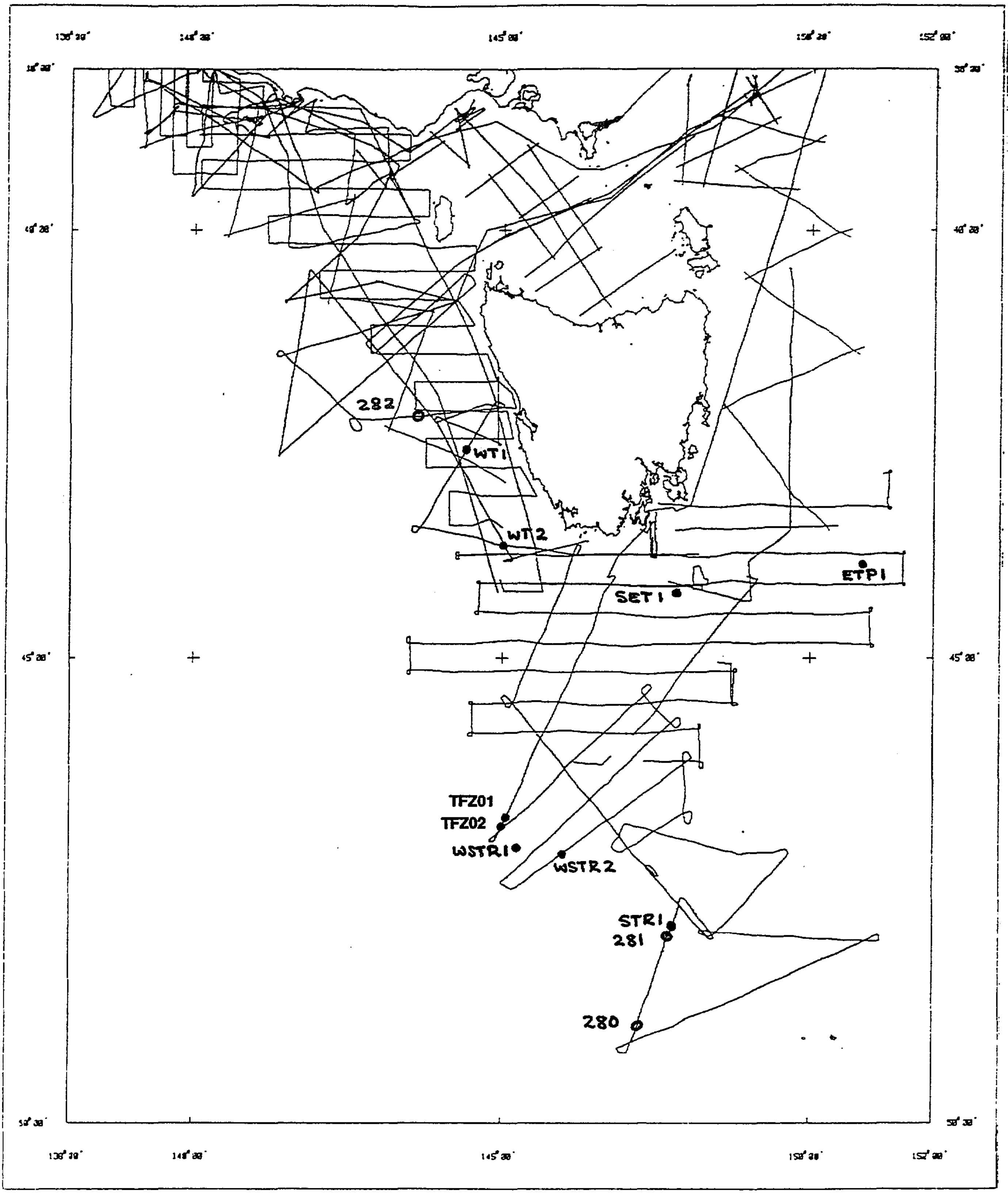


Figure 8. Map of the offshore Tasmanian region showing location of multichannel seismic tracks not shown in Figure 7. Locations of DSDP Sites and proposed ODP sites are also shown.

water benthic foram assemblage in one core. Above the Oligocene unconformity is 42 m of early Miocene foram and glauconite bearing nannofossil marl. Late Miocene nannofossil ooze, 7 m thick, disconformably overlies the early Miocene sequence, and is overlain by a veneer of Pleistocene ooze. There is little in this well to suggest that it was in deep water until the margin started to subside in the Oligocene, and it may be that the basalt is not oceanic at all. Total core recovery was only 20%.

Two DSDP wells were drilled on or near the South Tasman Rise (Kennett, Houtz et al., 1975A). Site 281 was drilled to 169 m, southwest of the culmination of the rise (Fig. 2), and bottomed in a quartz-mica schist of latest Carboniferous age (305 Ma). This is unconformably overlain by a six metre thick, late Eocene, basement conglomerate consisting of angular clasts, dominantly of schist, with lesser quartz, quartzite, glauconite, glauconitic sandstone and granite. This contains a battered assemblage of benthonic forams, and was a locally derived, shallow-water, high-energy deposit, laid down during the initial transgression across the subsiding South Tasman Rise. It is overlain by 3 m of detrital sand and nanno chalk. The upper 28.5 m of late Eocene sediment consists of greyish-olive glauconitic sandy silt and silty clay, with abundant forams, radiolarians, diatoms and sponge spicules. Neritic nannofossils and benthic forams in older strata point to deposition in outer shelf or upper bathyal depths, whereas the presence of shallow-water benthic forams points to shelf deposition later.

Unconformably overlying the late Eocene sequence there is 3 m of late Oligocene glauconite-rich detrital sand, unconformably overlain by 79 m of Miocene foram-nanno ooze and 36 m of Plio-Pleistocene foram-nanno ooze. Total core recovery was a relatively high 62%.

Site 280 was drilled to 524 metres, in deep water southwest of the South Tasman Rise (Fig. 2), and bottomed in an "intrusive basalt", almost certainly associated with oceanic crust. It penetrated a veneer of late Miocene to late Pleistocene clay and ooze underlain, beneath a sampling gap, by 55 m of siliceous early Oligocene sandy silt, and 428 m of middle Eocene to early Oligocene sandy silt, containing chert in the upper 100 m and glauconite and manganese micronodules below that. The lower 200 m is rich in organic carbon (0.6-2.2 %). All sediments are presumed to be abyssal types, and a brown organic stain suggests reducing conditions in parts of the late Oligocene and early Miocene. Total core recovery was only 19%.

Site 283 was drilled to 592 m, on the abyssal plain east of the East Tasman Plateau. It recovered entirely abyssal sediments above 4 m of pillow basalt. The sedimentary sequence consists of about 13 m of Plio-Pleistocene zeolitic clay, 163 m of late Eocene siliceous ooze, 139 m of M Eocene silty clay, and 273 m of Paleocene silty clay with some chert. Total core recovery was a very low 10%.

4.3. *Tasmante (L'Atalante)* swath-mapping survey

AGSO Cruise 125 used the French research vessel *L'Atalante* on an exchange basis for a swath-mapping survey of 200 000 km^2 of the area off Tasmania.The generalised results are displayed as bathymetry in Figure 7, and in three-dimensional form in Figure 9.

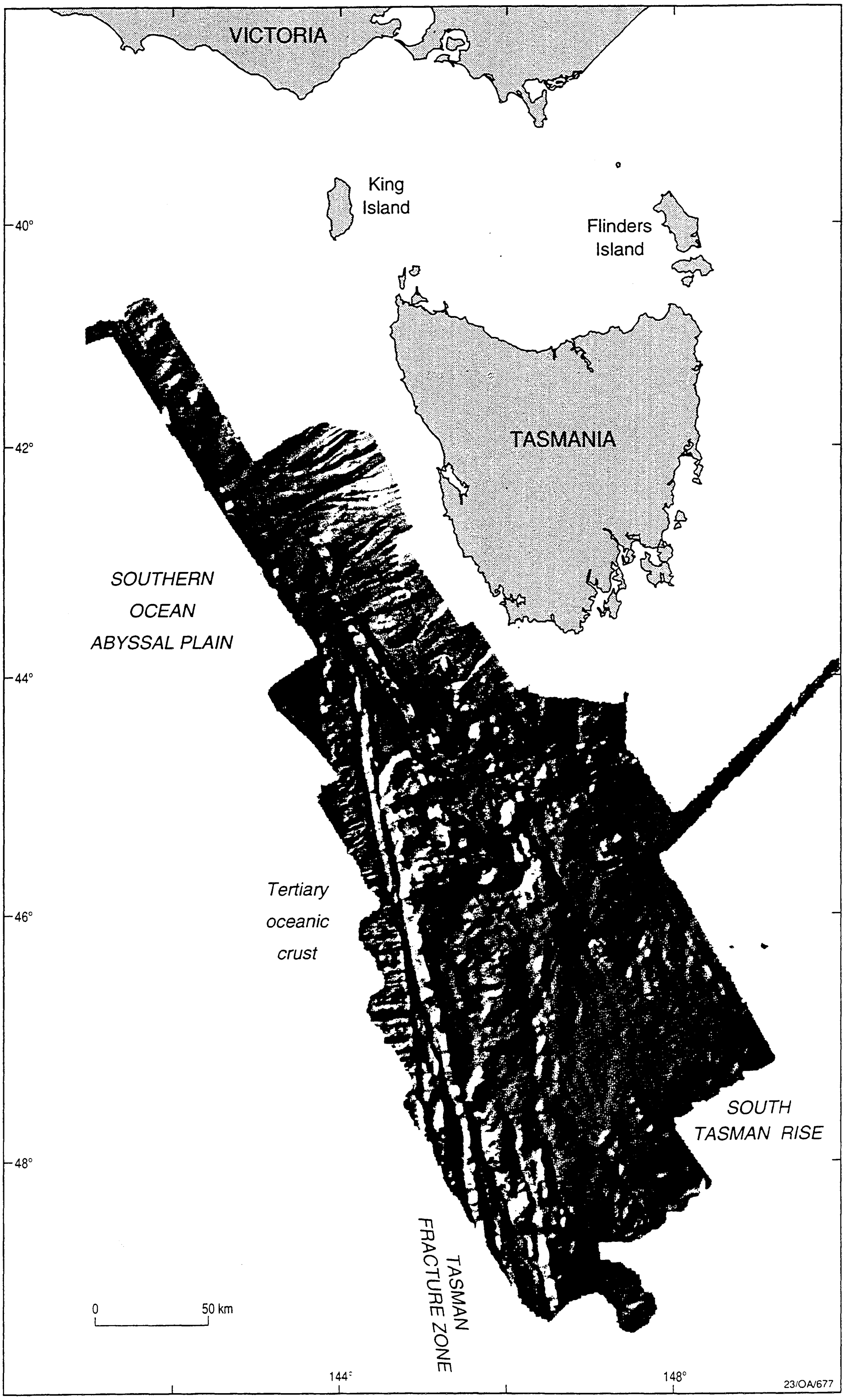


Figure 9. Relief diagram of the area swath-mapped off Tasmania on the *Tasmante* cruise.

The following discussion is drawn largely from Exon et al. (1994). Some aspects of the results were published by Exon, Hill & Royer (1995) and Hill, Exon & Royer (1995). The Simrad EM12D swath-mapping system is capable of mapping the sea bed in a swath up to 22 km wide at 20 km/hour, and of producing final bathymetric contour maps and images of the sea floor aboard ship. The *Tasmante* (from Tasmania and *L'Atalante*) cruise started in Auckland and ended in Adelaide.

The swath-mapping system, high speed seismic system, echosounder, magnetometer and gravity meter were deployed successfully throughout. About 13 600 km of data were recorded on the South Tasman Rise (STR) and west Tasmanian margin. All data were recorded digitally with the exception of the 3.5 kHz echosounder profiles. Seismic penetration of 2 seconds below sea bed was common. The very accurate bathymetric maps and sonar images arising from this survey provide an unequalled source of structural information.

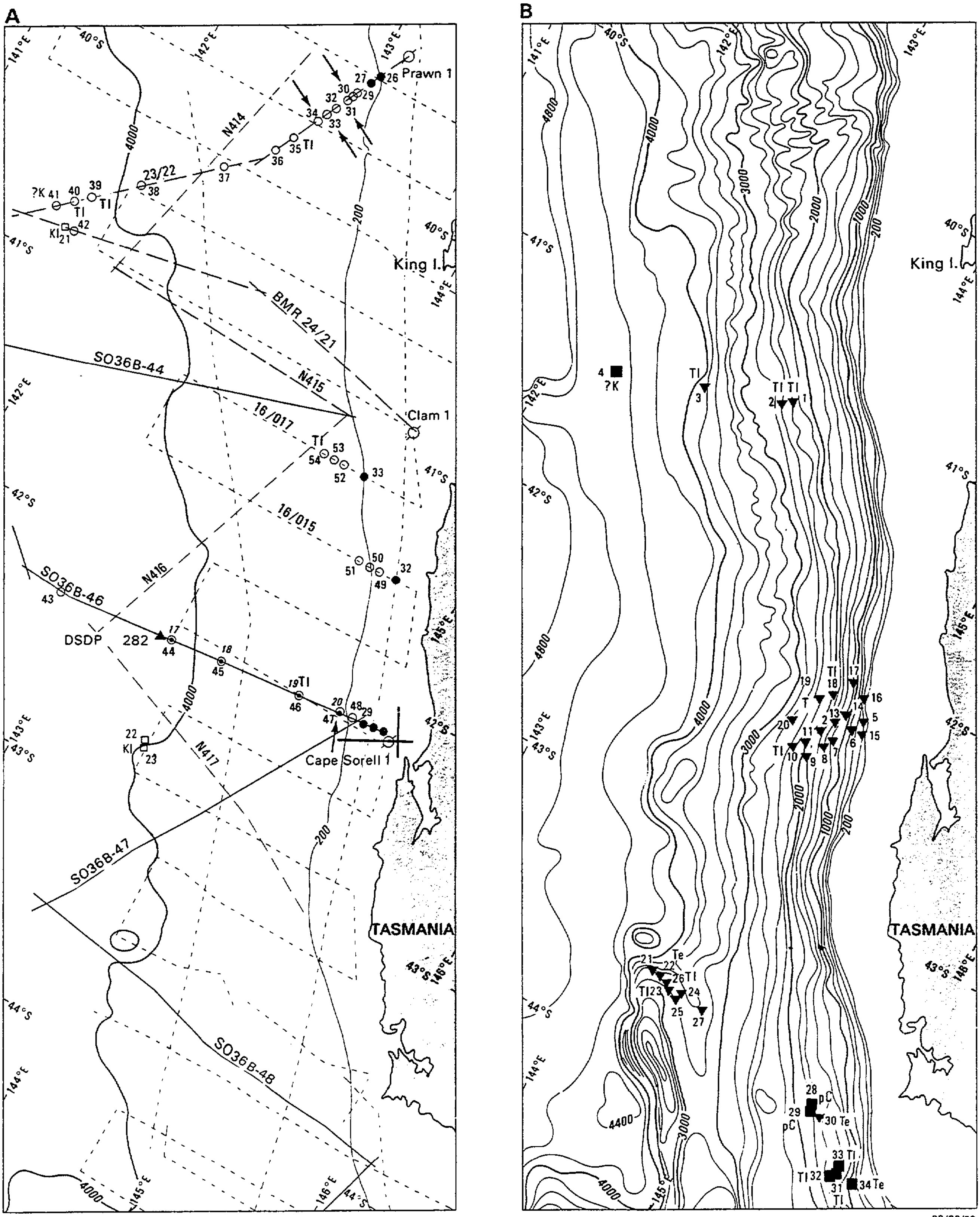
The maps defined bathymetry and surface texture with a degree of accuracy and rate of coverage unobtainable in any other way, and helped to clarify the region's structural pattern and Cretaceous-Tertiary tectonic history, the latter strongly influenced by the final separation of Australia and Antarctica about 40 million years ago. Large-scale sedimentary structures and patterns were mapped to help elucidate Tertiary sedimentary history.

4.4. Summary of sedimentological knowledge

West Tasmanian margin

Micropalaeontological studies carried out further west on the Australian margin have shown that, as the rate of seafloor spreading dramatically increased during the mid Eocene: the ocean trangressed from west to east, first entering in the Great Australian Bight and finally reaching the eastern Otway Basin (Shafik, 1990); marine influences on biota and sedimentation became apparent (Shafik, 1983); short-lived currents in bathyal depths scoured older (Cretaceous) rocks, redepositing the fine fraction on the continental margin (Shafik, 1985); the incursion of the proto-Leeuwin Current from the west increased surface water temperatures (Shafik, 1990), probably to a level similar to that already established east of the barrier due to the effects of the East Australian Current. Shafik (1992) showed that the mid Oligocene unconformity is associated with widespread erosion at bathyal depths, but deposition and preservation on the shelves, and deep-sea hiatuses intimately connected with climatic changes to cooler regimes. These effects should also be apparent in cored sections west of Tasmania.

The stratigraphy of petroleum exploration wells on the continental shelf was summarised by Moore et al. (1992). The Upper Cretaceous sequence is thickest, 1590 m, in Prawn No. 1 well, north of King Island (Fig. 10). It consists of marginal marine to fluviatile sandstone, siltstone, mudstone and conglomerate. The Tertiary sequence is probably disconformable on the Upper Cretaceous sequence. Non-marine to shallow marine, Paleocene to lower Eocene fining upwards sequences are present in all four exploration wells, and are by far the thickest, about 2250 m, in Cape Sorell No.1 west of Tasmania (Fig. 10). The middle Eocene to lower Oligocene sequence is more calcareous, consisting of shallow marine sandstone, marl and limestone, and is thickest, 375 m, in Cape Sorell No.1. Above a major



- - - - *BMR Continental Margin survey 1970–73*

— — *Shell 'Petrel' survey*

—— —— *BMR Bass Strait survey*

1987 Rig Seismic stations

● 17 *Grab*

○ 18 *Core*

□ 19 *Dredge*

• 20 *Heatflow*

——▸ *Gas anomaly*

━━━ *Amoco 'West Tasmania Basin' survey*

——— *BGR 'Sonne' Cruise SO-36, 1985*

Age of oldest rock found

TI Late Tertiary (incl late Oligocene)

Te Early Tertiary

Kl Late Cretaceous

Pz Palaeozoic

p€ Precambrian

0 at 42°S 100km

▼ *Sonne core*

■ *Sonne dredge*

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Figure 10. Map showing the location of most seabed sampling sites off west Tasmania.

unconformity, the upper Oligocene and younger sediments are dominantly shelfal marl and limestone. They are thickest, 617 m, in Prawn No. 1.

DSDP Site 282 results (locations in Fig. 2) are covered in Section 4.2 and will not be repeated in any detail here. They show that far down on the continental slope a thin Neogene carbonate sequence is cut by unconformities, and unconformably overlies 250 m or more of late Eocene to middle Oligocene marine mudstone.

Grab, vibrocore, core and dredge samples from the west Tasmanian margin have provided a great deal of valuable information. The most significant sampling locations are shown in Figure 10. They are discussed in Hinz et al. (1985, 1986), Exon, Lee & Hill (1989), Exon et al. (1992), and Exon et al. (1995). A general summary of the results is given in Table 4. All the Late Cretaceous, Paleocene and Eocene siliciclastic sediments are interpreted as shallow or restricted marine, and the Eocene limestones are also shallow marine. Above the Oligocene unconformity, the effect of the collapse of the margin westward is evident in the sediments, with those near Tasmania generally being shallow marine, but those further west being deposited in increasingly deep water.

Table 4: Character and age of west and southern Tasmanian seabed samples (south of 40°S)

Sequence	Stations
Pleistocene to Recent bryozoal shelf sands and muddy sands	67/GS 28-31; 78/GS1-9; 78/VC 1 & 2; 78/GC 8-17; 4 by 147/VC
Pleistocene to Recent oozes and turbidites	23 *Sonne* cores, 18 BMR 67 cores, 16 BMR 78 cores; 5 AGSO 147 cores
Miocene to early Pliocene limestone, chalk, marl, ooze and mudstone	9 *Sonne* cores, 2 BMR 67 cores, 5 BMR 78 cores
Late Oligocene to early Miocene shelf limestone	2 *Sonne* dredges, 2 AGSO 147 dredges
Late Oligocene marl and mudstone	2 BMR 67 cores
M Eocene shelf limestone	2 *Sonne* dredges
E-M Eocene nearshore marine mudstone	2 *Sonne* cores, 1 BMR 78 core, 1 AGSO 147 core
Paleocene restricted marine mudstone	1 BMR 78 dredge
Late Cretaceous shallow marine mudstone and sandstone	2 BMR 67 dredges, 1 BMR 78 dredge
Basalt	1 *Sonne* dredge, 1 BMR 78 dredge, 5 AGSO 147 dredges
Palaeozoic or Mesozoic sandstone, grit or metasediment	3 *Sonne* dredges, 1 BMR 78 dredge, 4 AGSO 147 dredges
Granites, gneisses, schists and related rocks	3 *Sonne* dredges, 1 BMR 78 dredge, 5 AGSO 147 dredges

South Tasman Rise

DSDP Site 281 (location in Fig. 2) was drilled high on the South Tasman Rise and contained 160 m of Cainozoic sediments above a basement high. It is described in more detail in Section 4.2. The uppermost 120 m consists largely of Neogene pelagic carbonates with late Oligocene glauconitic sand toward the base, unconformably overlying a veneer of early Oligocene glauconitic sand at the base. This unconformably overlies about 40 m of late Eocene mudstone, sandstone and basal conglomerate.

Many sea bed samples were taken from the South Tasman Rise by R.V. *Sonne* in 1985, and have been described by Hinz et al. (1985) and Bolton et al. (1988). More samples were taken by *Rig Seismic* in 1995 (Exon et al., 1995). Both sets of samples are summarised in Table 5, and the *Rig Seismic* sample locations are shown in Figure 11.

Table 5: Character and age of South Tasman Rise seabed samples

Sequence	*Sonne* Stations
Pleistocene to Recent carbonate ooze or foram sand	16 *Sonne* and 16 AGSO 147 cores
Pliocene carbonate ooze	4 *Sonne* cores
Oligocene - Miocene carbonates	1 *Sonne* core and 6 AGSO 147 dredges
Eocene glassy zeolitic mudstone with radiolarians	2 *Sonne* dredges & 3 cores, 12 AGSO 147 dredges
? Eocene palaeosol	1 *Sonne* core
Tertiary basalt, basaltic breccia and hyaloclasite	1 *Sonne* dredge and 13 AGSO 147 dredges
Basic plutonics	8 AGSO 147 dredges
Acid volcanics	1 AGSO 147 dredge
Palaeozoic sediments	1 *Sonne* core and 7 AGSO 147 dredges
Metasediments	8 AGSO 147 dredges
Granite, schist, gneiss, pegmatite	1 *Sonne* and 17 AGSO 147 dredges

The sampling results show that the history of the Cretaceous and Paleocene in the two areas, the west Tasmanian margin and South Tasman Rise, was probably similar. Clearly there were major differences in the Eocene, when the northern area saw the deposition of shallow marine deltaic sediments and limestones, while the southern area saw the deposition of glassy radiolarian-bearing glauconitic mudstones in a shallow sea that was restricted on occasions. As Australia cleared Antarctica there was a period of submarine erosion in both areas, forming the Oligocene unconformity, and both areas subsided steadily. However, the southern area sank vertically as a block, whereas the west Tasmanian margin rotated downward from a hingeline near the coast, so that the further from Tasmania, the deeper the water. In many southern areas, the Circum-Antarctic Current scoured most Neogene sediments away, whereas thick late Oligocene to Recent carbonate sediments are present in depocentres off west Tasmania and east of the South Tasman Rise.

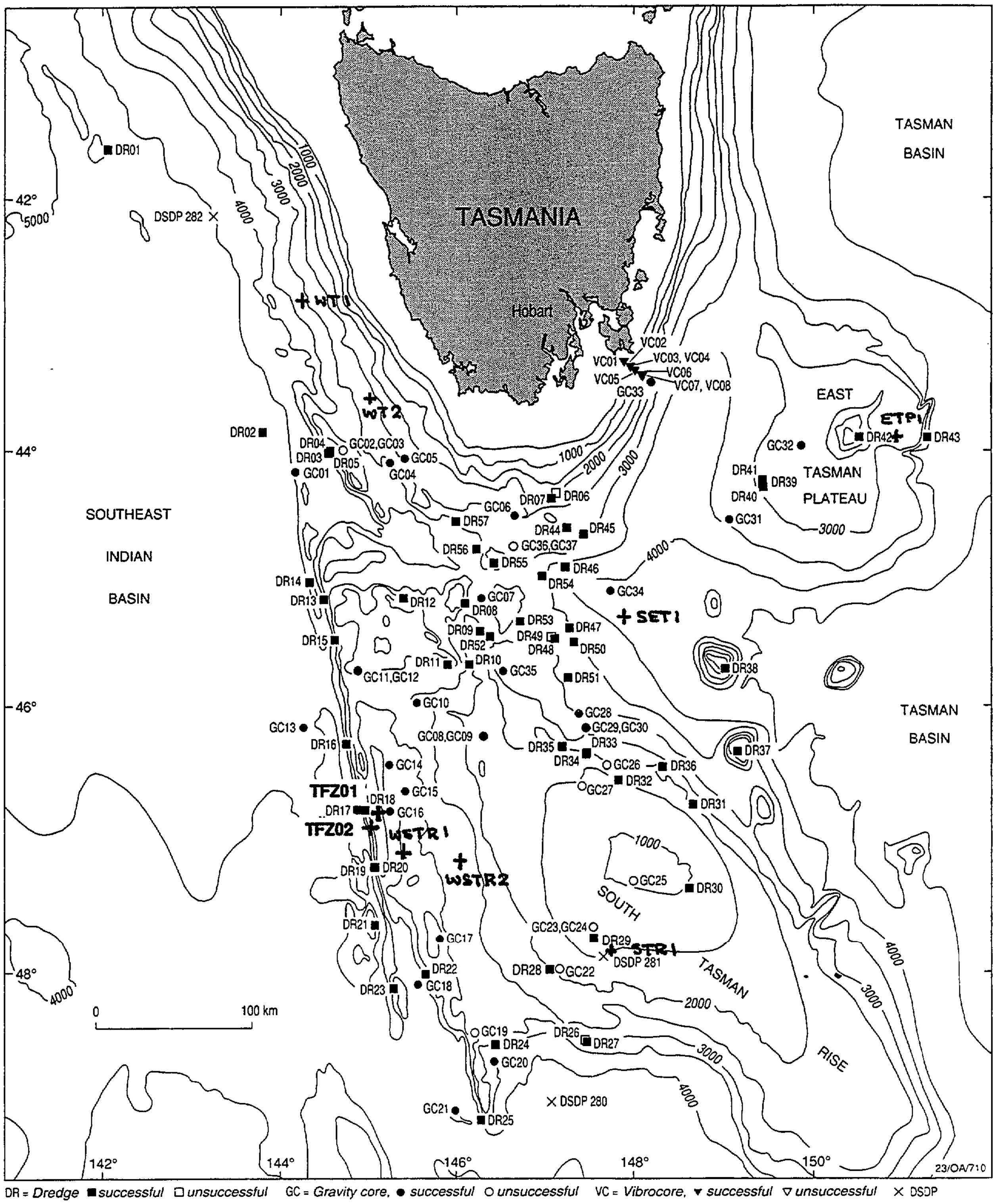

Figure 11. Map showing the location of the seabed sampling sites from AGSO Cruise 147 on the South Tasman Rise and East Tasman Plateau (after Exon et al., 1995).

East Tasman Plateau

Apart from volcanics and carbonates dredged by fishermen from the Eocene Soela Seamount, the only other rock samples we know of from the East Tasman Plateau come from six stations occupied by *Rig Seismic* on AGSO Cruise 147 (Exon et al., 1995). The *Rig Seismic* stations are summarised in Table 6.

Table 6: Character and age of *Rig Seismic* East Tasman Plateau seabed samples

Sequence	Stations
Pleistocene to Recent carbonate ooze or foram sand	1 AGSO 147 core
?Eocene mudstone	1 AGSO 147 dredge
Tertiary basalt, basaltic breccia and hyaloclasite	3 AGSO 147 dredges
Acid volcanics	1 AGSO 147 dredge
Palaeozoic sediments	1 AGSO 147 dredge
Metasediments	1 AGSO 147 dredges
Granite, schist, gneiss	2 AGSO 147 dredges

The plateau clearly is a continental block, and seismic profiles show up to 1500 m of probably Cainozoic section above basement in places. This section is of similar appearance to the Cainozoic section elsewhere, and certainly consists of Neogene pelagic carbonates above Palaeogene shallow marine mudstones.

5. SCIENTIFIC OBJECTIVES

5A. Primary objectives: palaeoceanography / sedimentary history

The primary ocean history objective of this proposal is to better determine the timing of the initial opening of the Tasmanian Seaway in the middle Cenozoic, the changes in palaeoenvironmental evolution of the seaway and the development of the Southern Ocean, and their influences on ocean circulation and global climate evolution. The proposed cored sequences will provide crucial information about the development of this crucial seaway in relation to the evolution of the Southern Ocean environment and Antarctic climate.

The Tasmanian region remains a key area to address such matters as:

1) The *Cretaceous-Tertiary* boundary event (2 sites: WT1 & TFZ02).

2) *Palaeogene sedimentary and climatic history* as recorded in this critical southern region. There is still only a partial isotopic record of the cool and warm events that need more detail to be fully understood. (4 sites: WT1, WSTR1, WSTR2, ETP1)

3) *Paleocene to middle Eocene deltaic history*, and the transgression of the Southern Ocean environment into the deltaic sequences as the rift formed between Australia

and Antarctica. This oceanic transgression proceeded from west to east as indicated by earlier-drilled sequences (DSDP 282 has early Eocene calcareous microfossils. At DSDP 281 they appeared later in late Eocene). The palaeogeography in the middle Eocene (40 Ma), as shown in Figure 3, illustrates how the deep ocean would have started its invasion from the west into the rifts that were forming between Australia and Antarctica in the Tasmanian region. Nannofossil evidence from the southern Australian margin confirms that this transgression proceeded eastward. Another question is whether the late Eocene varves dredged from the western South Tasman Rise represent restricted marine conditions that deposited organic-rich shales in places (as suggested by high organic carbon values in the DSDP holes). (3 sites: WT1, WSTR1, WSTR2).

4) The opening history of the *late Eocene through Oligocene*, when open marine conditions first developed in this region. This was a key time in the development of the seaway south of Australia. An important question is how long the calcareous assemblages on either side of the South Tasman Rise remained isolated. How long did they persist, and when did Indian and Pacific Ocean assemblages come into contact. Nannofossil evidence from several hundred kilometres north suggests that differences persisted at least until the late Oligocene. Another question is whether a warm current started to enter the region periodically from the west, as does the Leeuwin Current today. The seismic stratigraphic evidence suggests that, at the proposed STR and ETP stratigraphic sites, there are relatively thick, well-bedded late Eocene to mid Oligocene sequences above the cross-bedded deltaic rocks and below the mid Oligocene unconformity. These are assumed to be open marine chalks suitable for detailed isotopic studies. Seismic and core evidence suggests that this sequence is missing from west Tasmania. It is possible that a stable isotope-based palaeoclimatic history could result from such an analysis of these carbonate deposits, although diagenetic alteration may cause problems with interpretations. Nevertheless, palaeontological data will be critical towards answering these questions. (3 sites: WSTR1, WSTR2, ETP1).

5) The development of the Tasmanian Seaway was one of the most crucial palaeoceanographic events in the history of Cenozoic ocean evolution. Its development, in conjunction with the opening of Drake Passage, led to the initial development of the Southern Ocean and of circum-Antarctic circulation. Continued northward movement of Australia, Tasmania and the South Tasman Rise led to continued expansion of the Southern Ocean, the Antarctic water mass, and the Circum-Antarctic Current during the middle and late Cenozoic. This led to progressive thermal isolation of the Antarctic continent, which fostered cryospheric development. Results from DSDP Leg 29 indicated an early Oligocene opening of the seaway (Kennett et al., 1972; Kennett, Houtz et al., 1975B) but the timing is not as well constrained as it should be. Also the timing of opening to deep waters relative to shallow waters needs to determined. It is possible that a diversity of data can be generated to determine the history of development of the open-ocean environment through the gateway and biogeographic consequences. Figure 3 represents the palaeogeography in the earliest Oligocene (34 Ma), and suggests that the initial breakthrough of the Circum-Antarctic Current may have occurred either south and west (WSTR1) or north (WT1) of the culmination of the South Tasman Rise. This proposal is complementary to that of Carter et al. (1993), dealing with the Southwest

Pacific gateway for deep ocean water, east of New Zealand. (3 sites: WT1, WSTR1 & WSTR2).

6) The details of the *Neogene climatic history* requires documentation, as revealed in pelagic carbonates, especially by isotope studies, in an area subject to the movement of the Subtropical Convergence and Polar Front, and Australia's drift northward widening the Southern Ocean. A transect of north-south sites (42-48°S) would examine the evolution of climate using carbonate sediments, along the lines of the generally lower latitude DSDP Leg 90 east of Australia (Kennett, von der Borch et al., 1986), and be complementary to the proposed relatively shallow-water and more northerly Southern Australian sites (Feary et al., 1995: ODP Proposal 367 - Revision 3). The sites would also document the expansion of the circum-Antarctic flow during the middle through late Cenozoic, examine the evolution of oceanic fronts, and possibly the incursions of a warm-water proto-Leeuwin Current during the Miocene and Pliocene. The area lies just north of the of the present (interglacial) Subantarctic and polar frontal regions, so is well-placed to monitor equatorward excursions of these water-mass boundaries, as reflected in changes in planktonic biota, deposition of ice-rafted debris, stable isotope ratios in planktonic foraminiferal calcite, and alkenone unsaturation ratios. Its position in a zone of high carbonate productivity will allow reliable stable isotope chronostratigraphies to be developed and tied to well-calibrated calcareous nannofossil biostratigraphic frameworks, as well as an opportunity to test the application of alkenone unsaturation ratios in a subpolar environment into the Neogene. (4 sites: WT1, WSTR1, WSTR2 & ETP1).

7) The global *Quaternary glacial-interglacial sedimentary history* is primarily driven by changes in northern hemisphere ice sheets. Associated movements occurred in the Subtropical Convergence and the Polar Front. This area is uniquely placed to document such changes in the Southern Ocean, because the shallow water allows calcareous fossils to be preserved, and because the present-day Subtropical Convergence is centred over the South Tasman Rise, and the Polar Front is not far to the south. Detailed isotope, sedimentologic, biostratigraphic, and alkenone studies should yield spectacular results. (one particularly good site: WSTR1).

Tools to be applied

Biotic:
Planktonic foraminiferal, radiolarian, and diatom biotic variations have all been thoroughly calibrated in terms of surface-ocean properties (especially SST (sea-surface temperature)) in the Southern Ocean, and a high-resolution site in the Subantarctic would provide a unique opportunity for intercomparison in the Plio-Pleistocene. All these biotic groups have provided reliable quantitative estimates of sea-surface properties for the late Pleistocene, and can probably be applied reliably (though perhaps semi-quantitatively) for the early Pleistocene and Pliocene.

Organic geochemical:
Alkenone unsaturation ratios provide a set of independent SST estimates, and since the alkenones are produced by coccolithophorids that bloom in summer, they may provide a unique opportunity to estimate seasonality when combined with siliceous biotic estimates. The alkenone approach can be applied through the late Pleistocene and semi-quantitatively

through the earlier Neogene, and has been thoroughly calibrated in Southern Ocean waters (Sikes & Volkman, 1993).

Stable isotopes:
The water depths and thicknesses of Neogene section on the South Tasman Rise sites (<700 m) should provide stable isotope records that are not altered by dissolution or burial diagenesis, at least in the upper 400-500 meters of section (Miller et al., 1987).

Carbon isotopes. Though there has been controversy over the interpretation of carbon isotopes in the Southern Ocean as "nutrient" tracers, their use as water-mass mixing tracers remains widespread. In particular the use planktonic-benthic carbon isotopic differences provide a record of the alteration of surface-water chemistry by biology and air-sea exchange, especially when combined with other nutrient tracers such a cadmium-calcium ratios.

Oxygen isotopes. These will provide records of global ocean chemistry that mainly reflect continental ice volume, though for the periods earlier than ~2.6 Ma the proportion of the isotopic signal that can ascribed to ice volume is not as well-known as for the later Neogene. Again the planktonic-benthic gradient can be used to provide some constraints on the evolution of the Southern Ocean thermal regime through the Neogene.

Biogenic sedimentation. The Subantarctic is an ideal area for the application of lithostratigraphy to composite section development and time-scale construction through orbital tuning, because the alternation of carbonate and siliceous sedimentation tracks the orbitally-related frontal migrations so reliably (Charles et al., 1991; Howard, 1992a; Howard & Prell, 1994). In addition, since carbonate and silica have such distinct grain densities, these lithologic variations will be detectable through continuous rapid whole-core measurements such as GRAPE bulk density measured as cores come up.

5B. Primary objective: formation and evolution of the transform margin of the western South Tasman Rise

Of all the ODP legs, only Leg 159, on the Côte d'Ivoire-Ghana margin off west Africa (Mascle, Lohmann, Clift et al., 1996), has addressed the formation of transform continental margins. This proposal intends to provide comparative information in an apparently similar marginal setting by drilling two shallow sites (TFZ01 & 02), on the western, 345°-trending, outer ridge of the STR that marks the continent-ocean boundary and the former sheared boundary with Antarctica. The ridge forms the continental extension of the oceanic Tasman Fracture Zone (TFZ) that extends southward to Antarctica. Such steep marginal ridges have resulted from translational stresses that were active between two continents along active transform faults. Mascle & Blarez (1987) have characterised the evolution of such margins as consisting of three stages: an intra-continental active transform fault, a continent-ocean active transform fault, and an inactive transform fault. We suggest on plate tectonic grounds (e.g. Rollet et al., in press) that the intra-continental phase lasted from 55 to 40 Ma, the continent-ocean phase from 40 to 30 Ma, and the inactive phase from 30 Ma to the present day.

In a similar fashion to ODP Leg 159 (Côte d'Ivoire) the tectonic objectives of the two TFZ sites are to:

1) better determine the tectonic processes that were involved in the formation of the TFZ marginal ridge;
2) document its deformation history during the successive stages of evolution;
3) constrain the timing, rate and degree of uplift and subsidence occurring along the ridge;
4) investigate the relationship between the thermal evolution of the ridge and the actively spreading oceanic crust that migrated southward beside it.

In addition, the TFZ02 site may provide important information on the magmatic processes that have occurred during the creation of this transform margin (intrusion or underplating).

5C. Secondary objective: plate tectonic history of four terranes

This proposal will address the history of three of the four poorly understood continental tectonic terranes related to the breakup of Australia-Antarctica: Tasmania, western South Tasman Rise, and East Tasman Plateau (ETP). Their role in the breakup history is clearly significant, and if better understood could constrain the breakup story.

Two of the presently proposed sites (WT1, TFZ02) would be drilled to basement, giving age and petrological information about that basement. All sites will give, via the overlying sediments, information on the subsidence history of the terranes. Four sites (WT1, WSTR1, TFZ01 & TFZ02) would be drilled into the presumed Cretaceous section. No Cretaceous rocks have ever been recovered from the STR and, if they were (or were not) recovered from sites on the western STR terrane, the history of the STR would be better understood.

6. RELATIONSHIP OF SCIENTIFIC OBJECTIVES TO ODP LONG RANGE PLAN

This proposal addresses a number of key JOIDES scientific objectives, as listed in the 1996 Long Range Plan, under both "Dynamics of Earth's Environment" and "Dynamics of Earth's Interior".

As regards the ***Dynamics of Earth's Environment***, the proposal addresses "Earth's changing environment" and "causes and effects of sea level change" in terms of:
1) *Orbital forcing* - High resolution cores will be taken in the latest Cretaceous and Cainozoic and many may show cyclicity. For example: known Eocene varves point to cyclic sedimentation; coastal upwelling is indicated by rich Palaeogene siliceous fossil assemblages and this may be cyclic.
2) *Rapid climatic change and internal feedbacks* - Cretaceous-Tertiary boundary changes and younger rapid Cainozoic (including Quaternary) variations will be further detailed. Do high-frequency variations such as the Heinrich events and interglacial coolings punctuate the Southern Ocean paleoceanographic record as they clearly do in Northern Hemisphere marine and ice cores (Broecker, 1994; McManus et al., 1994)?
3) *Long-term changes and abrupt events* - Cainozoic slow and fast climatic changes.

4) *Global sea level change* - e.g. Oligocene and late Miocene sea level falls from cooling; Miocene tectonic movements from Indonesian collision.

It may also prove to address:

1) *Sea level & facies architecture* - The nature of the Palaeogene deltas in a continental borderland setting, and their relationship to sealevel fluctuations.
2) *2) Carbon cycling from seafloor to base of biosphere* - Organic carbon cycling associated with upwelling and barred basins in the Palaeogene shallow marine sequences (known varves provide evidence of protected sedimentation); black shales in enclosed Palaeogene basins (sediments are known to be organic-rich and slightly gas-bearing in places). The South Tasman Rise lies in the Subantarctic Zone, an area of strong atmosphere-ocean flux of carbon dioxide today (due both thermodynamic and biologic pumping) and modulation of this sink on glacial-interglacial time scales is likely to have been important for atmospheric carbon dioxide variations of the past (Howard, 1992b).

As regards ***Dynamics of Earth's Interior***, it addresses both "deformation of the lithosphere" and "transfer of heat and materials from Earth's interior" in terms of:

1) *Translational settings* - Two holes near the TFZ marginal ridge would elucidate the geological history of the transform marginal ridge on western South Tasman Rise, that was associated with the 345° shearing movement between Australia and Antarctica. Their value would be in helping to further refine the global model for transform margins developed with the help of ODP Leg 159. As compared to Leg 159 this proposal has the added benefit of the possibility of drilling into a basic intrusion related to transtensional movement on the transform fault.
2) *Vertical tectonic processes* - Uplift and subsidence of the TFZ marginal ridge over time as documented in two proposed sites.

7. SUMMARY OF PROPOSED SITES

We propose four sites to meet our ocean history objectives, one off west Tasmania (WT1), two on the western South Tasman Rise terrane (WSTR1 & 2), and one on the East Tasman Plateau (ETP1). We also propose two shallow tectonic sites on the westernmost ridge of the South Tasman Rise to elucidate the tectonic history of this transform margin (TFZ01 & 02). There are three alternate sites, one off western Tasmania, one near DSDP Site 281 on the eastern South Tasman Rise terrane, and one in the sediment drift between the South Tasman Rise and the East Tasman Plateau. A seismic two-way velocity of 1700 m/s has been used to calculate Neogene thickness, and 2200 m/s has been used to calculate Palaeogene thickness. The proposed sites are listed in Tables 7A & B and their locations are shown in Figures 2 and 7. Figure 12 shows the spatial relationships of the four sites proposed for the western South Tasman Rise. All six sites are covered by swath-mapping. No particularly difficult drilling is expected, and it is hoped that only one hole (WT1) will require use of a small re-entry device.

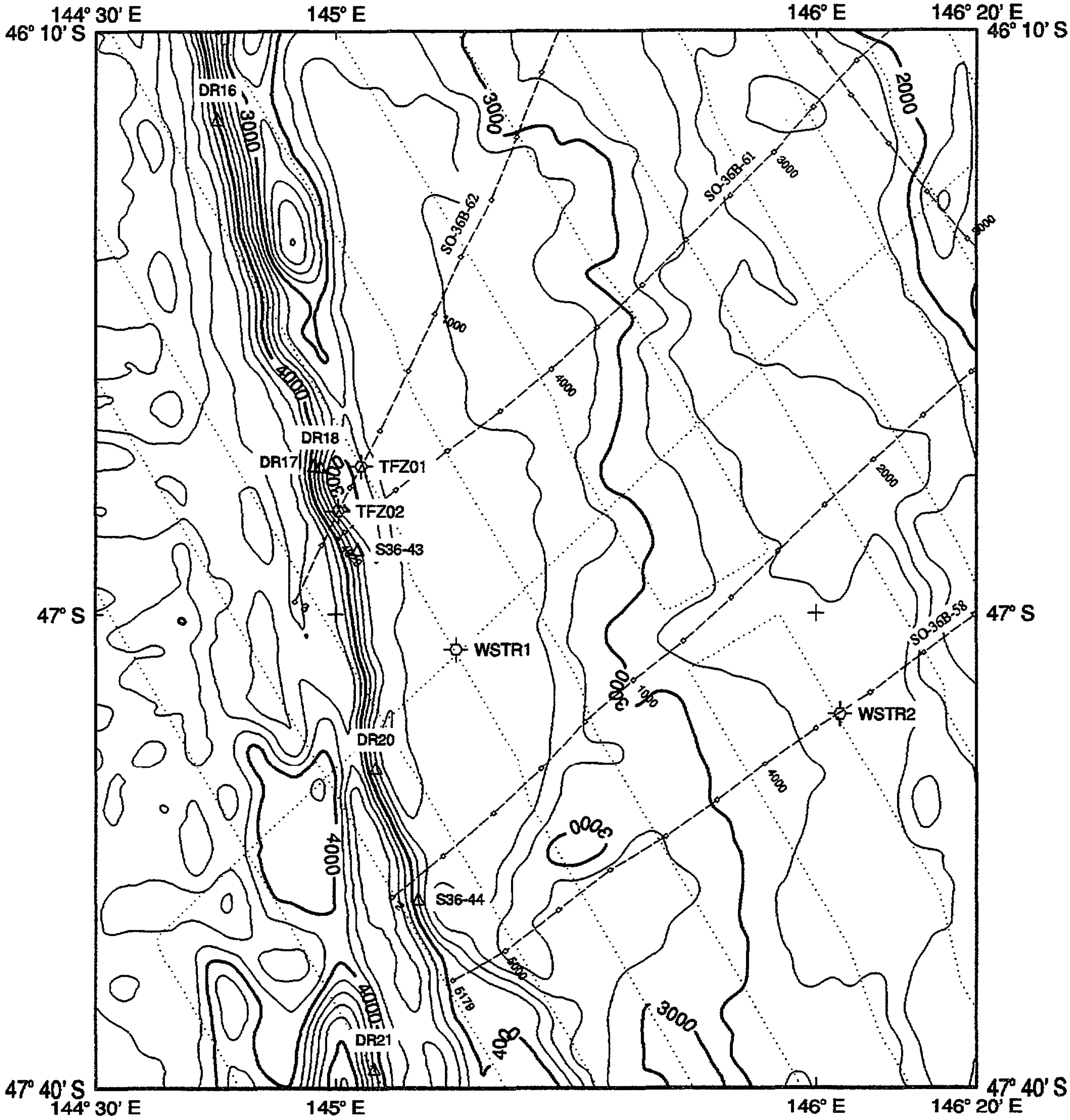

Figure 12. Map relating the four proposed sites on the western South Tasman Rise to bathymetry from *Tasmante* swath-mapping, and seismic profiles (dotted lines = 1994 *Tasmante* cruise; dashed lines = 1985 *Sonne* Cruise 36B).

Table 7A: Proposed high priority drill sites off Tasmania

Site (priority)	Lat (S) Long (E)	Water depth (m)	Penet-ration (m)	Neog thick (m)	Palaeog thick (m)	Finish in	Comments
WT1	42° 37' 144° 24.5'	2500	1245	680	440	Continental basement	Complete Cainozoic Indian Ocean section, K/T boundary and basement (NW)
WSTR1	47° 03' 145° 15'	3570	1035	380	605	Late Cretaceous (50 m)	Complete Indian Ocean Pliocene to Recent and Palaeogene sequences, and K/T boundary (SW)
TFZ01	46° 47.5'S 145° 03.2'E	3100	500	30	420	Late Cretaceous	Tectonised sequences of TFZ: mainly Palaeogene (SW)
TFZ02*	46° 51.3'S 145° 00.35'E	3300	200	20	30	Basic intrusive basement	Tectonised sequences of TFZ: 100 m K. 50 m into basic intrusion (SW)
WSTR2	47° 08.5' 146° 03'	2730	580	470	110	Late Eocene	Complete E. Neogene sequence, into L. Eocene (SW)
ETP1*	43° 54.6' 150° 54.6'	2800	615	365	250	Eocene	Complete Neogene Pacific Ocean section; complete Eocene pelagic section (NE)**

The total coring program for these sites is 4145 m.
**No second seismic profile crossing yet available.*
*** This site could be extended further into the Palaeogene, and indeed to basement at 1105 m.*

Table 7B: Proposed alternate drill sites off Tasmania

Site	Lat (S) Long (E)	Water depth (m)	Penet-ration (m)	Neog thick (m)	Palaeog thick (m)	Finish in	Comments
WT2	43° 43.5' 145° 02'	2920	855	255	550	Late Cretaceous (50 m)	Complete Cainozoic Indian Ocean section, K/T boundary (NW)
STR1	47° 51' 147° 52'	1460	1160	180	930	Late Cretaceous (50 m)	Complete Palaeogene barrier sequence and K/T boundary (south)
SET1*	45° 18.5' 147° 55'	4055	500	400	100	late Eocene or early	Complete Neogene Pacific Ocean drift section (east)

The total coring program for these sites is 2515 m.
**No second seismic profile crossing yet available.*

8. DRILLING STRATEGY

1) The sites should be drilled in an arc from west to east as drilling proceeds from the Indian to Pacific Oceans. The total distance between sites is 640 nautical miles, representing a travel time of 2.7 days.

2) A north-south transect (WT1, WSTR1 & WSTR2) will extend from well north of the Sub-Tropical Convergence, to almost as far south as the Polar Front. Such a transect will aid the comparison of cold-water siliceous biostratigraphy with temperate carbonate microfossil biostratigraphy.

3) An east-west transect (WT1, WSTR1, WSTR2 & ETP1) will provide information on the Cainozoic reduction of microfossil provinciality between the Indian and Pacific Oceans as the barrier of the South Tasman Rise became less great with time.

4) All four palaeoceanographic sites (WT1, WSTR1, WSTR2 & ETP1) should be double cored with the APC/XCB system to about 200 m (refusal) in the Neogene to increase the undisturbed recovery. The XCB will be continued to about 500 m in the first APC hole. The remainder of each site will be drilled in a third hole with the RCB, after washing to within 50 m of the XCB depth. It is hoped that re-entry with a mini cone will prove unnecessary, except in WT1; it may prove necessary also in WSTR1.

5) Sites WT1, WSTR1, WSTR2 & ETP1 should be logged with four Schlumberger tool strings: seismic stratigraphic, lithoporosity, formation microscanner (FMS), and the combination geochemical logging (GLT). Exploratory tectonic sites would omit at least the seismic stratigraphic run.

6) The two shallow tectonic sites, TFZ01 and TFZ02, should simply be rotary drilled (RCB) to total depth, as the stratigraphic sequence is expected to be severely deformed. For the same reason, logging can be sensibly reduced to two runs: formation microscanner (FMS) and combination geochemical logging (GLT).

7) Estimates of drilling plus logging time for the priority sites are included below in Table 8A (alternates in Table 8B). The assumption is that three holes will be drilled at sites WT1, WSTR1, WSTR2 & ETP1: APC/XCB to 500 m; a second APC to 200 m; wash down to 450 m and RCB to total depth. Re-entry with a minicone is included in Site WT1. At tectonic sites TFZ01 & TFZ02 drilling would be reduced to one RCB hole.

8) The estimates suggest that time in the region for all six holes would be about 52 days, including sites surveys and transits between sites.

Table 8A: Estimated time on station for high-priority drill sites off Tasmania

Site (transit from last)	Latitude Longitude	Water depth (m)	Penetration (m)	Neogene thickness (m)	Palaeogene thickness (m)	Drill + logging time
WT1	42° 37'E 144° 24.5'S	2500	1245 (100 m Cretaceous; 20 m basement)	680	440	15 days
WSTR1 (30 hrs)	47° 03'S 145° 15'E	3570	1035 (50 m into Cretaceous)	380	605	11 days
TFZ01 (2 hrs)	46° 47.5'S 145° 03.2'E	3100	500 m (50 m into Cretaceous)	30	420	4 days (RCB & log)
TFZ02 (1 hr)	46° 51.3'S 145° 00.35'E	3300	200 m (100 m Cretaceous; 50 m basic intrusion)	20	30	2 days (RCB & log)
WSTR2 (5 hrs)	47° 08.5'S 146° 03'E	2730	580	470	110	7 days
ETP1* (26 hrs)	43° 54.6'S 150° 54.6'E	2800	615	365	250	8 days
Total			**4145**	**1945**	**1705**	**47 days**

** ETP1 could be extended profitably if time were available; the original concept was to drill to basement at 1105 m (see Section 9A).*
Travelling within the region at 10 knots = 2.7 additional days (64 hrs above)
Site surveys = 2 additional days, especially at TFZ02
Assumed transit distance = 1650 Miles = 7 days (from Hobart and to Auckland)
So, total estimated time = 47+2.7+2 = 52 days, plus 7 days transit to and from the region.

Table 8B: Estimated time on station for alternate drill sites off Tasmania

Site	Lat (S) Long (E)	Water depth (m)	Penetration (m)	Neogene thickness (m)	Palaeogene thickness (m)	Drill + logging time
WT2	43° 43.5' 145° 02'	2920	855 (50 m into Cretaceous)	255	550	9 days
STR1	47° 51' 147° 52'	1460	1160 (50 m into Cretaceous)	180	930	13 days
SET1	45° 18.5' 147° 55'	4055	500	400	100	8 days
Total			3035	1305	1630	37 days

9A. INDIVIDUAL SITE SUMMARIES: PRIMARY SITES

West Tasmania: WT1

This site is designed to fully penetrate thick Neogene and Palaeogene sections, and the latest Cretaceous, before reaching continental basement, at the crossing of seismic lines *Tasmante* 52 and *Sonne* 36B-47 in a present water depth of 2500 m (Figs. 2, 13 & 14). The site was in shallow water until the late Oligocene, and deepened steadily thereafter. Thus for most of its history it lay in water far shallower than the present depth.

The site will drill a thick Neogene sequence (about 700 m), and will thus provide a high-resolution carbonate-rich sequence on the Indian Ocean side of the STR. The site is on the mid-slope west of Tasmania and southeast of DSDP Site 282. Site 282 was on a structural high and the Neogene sequence was only 192 m thick and contained three marked unconformities. The average sediment velocity from comparing seismic profiles with the well depth is about 2000 m/second, but velocities in the Neogene ooze are more likely to be about 1700 m/second, and we use that here in our calculations.

The site will help to more accurately date the mid-Oligocene unconformity, and document the effects of the development of the Circum-Antarctic Current on the overlying sediments through variations in grainsize and composition.

The Palaeogene sequence of shallow marine mudstone (410 m) was cored (103 m) at DSDP Site 282, where it consisted of dark coloured, organic-rich late Eocene nannofossil bearing mudstone, believed to have been deposited in a deep basin with restricted circulation (Kennett, Houtz et al., 1973). In addition, two middle Eocene *Sonne* cores consisting of organic-rich, paralic, deltaic fossiliferous mudstone (SO36/22SL & 30KL: Hinz et al., 1995) were taken on seismic profile SO36B-48. By comparison with ODP Leg 159, on a similar transform margin off west Africa (ODP Leg 159 Scientific Party, 1995), there is a good chance that anoxic sediments will have accumulated in a silled basin on the margins of the opening Southern Ocean.

At WT1 the section to 0.8s (680 m) is moderately transparent on most seismic profiles, and unconformably overlies a sequence that is finely cross-bedded on high resolution profiles. Coring at two sites on the margin has shown the cross-bedded section to consist of shallow marine Eocene mudstone, and it is assumed that the Oligocene unconformity forms the base of the overlying transparent sequence. Within the Neogene sequence there is some downlap onto a reflector at 0.45 seconds. We propose to drill through all 0.37 s (410 m) of the cross-bedded Palaeogene sequence to determine its age and environment of deposition. By drilling this site to basement about 0.1 s (105 m) of Cretaceous deltaic rocks should be penetrated. As the seismic sections suggest the K/T boundary is conformable, there is a good chance of getting valuable information about the terminal Cretaceous extinctions. The approximate total depth, including 20 m of basement, is estimated to be 1245 m, and will require re-entry. The site is not structured and is believed to be safe as regards petroleum entrapment.

West South Tasman Rise: WSTR 1

This site is close to the western ridge of the STR (Fig. 12) and is designed to fully penetrate a thick young Neogene section and a thick Palaeogene section. The younger part of the Neogene section is seismically transparent, and has accumulated in the lee of the Tasman Fracture Zone, which forms a ridge to the west. This transparent young facies is probably Pliocene to Recent in age and is seldom present on the current-swept South Tasman Rise. In fact this may be the best place to obtain a full record of the Pleistocene glacial signal in this part of the Southern Ocean. The underlying older Neogene section is well bedded but hummocky in character, and probably consists of chalks with some hiatuses, as does the seismically similar underlying late Palaeogene sequence. By comparison with Site WSTR2, further east, the lowest part of the Neogene section appears to be absent here, so WSTR1 is not a good site for examining the mid-Oligocene unconformity and the immediately overlying sediments. However, it is a good site for charting the incoming of open marine conditions in the Eocene (as represented by calcareous plankton), and for the analysis of the early-rift deltaic sediments.

The Palaeogene section should consist of relatively thin late Eocene to early Oligocene chalk overlying relatively thick Paleocene to Eocene shallow marine mudstone. *Sonne* coring and *Rig Seismic* dredging, and DSDP Site 281, suggest that the mudstone facies is greatly different to that on the Tasmanian margin (DSDP 282, *Sonne* cores and WT2 proposal). On the South Tasman Rise, the facies is of grayish olive to greenish gray late Eocene shelf to upper slope mudstone, with abundant microfossils in places, most of them siliceous. AGSO dredges, from the western margin of the South Tasman Rise, contain late Eocene dinocysts of glacial character, and AGSO 147DR14/A6 is a varved mudstone, with light-dark varves millimetres thick, distinguished by the presence or absence of dark organic matter. By comparison with ODP Leg 159, on a similar transform margin off west Africa (ODP Leg 159 Scientific Party, 1995), there is a good chance that anoxic sediments will have accumulated in a silled basin on the margins of the opening Southern Ocean.

The proposed site is at the intersection of multichannel seismic profiles *Tasmante* 4 and 9 in water now 3570 m deep but much shallower in the past (Figs. 2, 7, 17 & 18). It is designed to penetrate 0.23 s (195 m) of Pliocene to Recent transparent ooze onlapping 0.22 s (185 m) of late Oligocene to Miocene ooze and chalk above the Oligocene unconformity. It should penetrate 0.1 s (110 m) of late Eocene to early Oligocene chalk, and 0.45 s (495 m) of Paleocene-Eocene mudstone, between the Oligocene unconformity and the Cretaceous-Tertiary boundary at 1.0 s (985 m). The Palaeogene mudstone sequence is prograded to the southeast, so is probably part of a shelf delta. Whether it is restricted to the Eocene or will contain a Paleocene sequence is unknown, and that presence or absence, along with the nature of the Cretaceous sequence, will provide important information about the breakup history of this transform margin. If 110 m of Late Cretaceous shallow marine sediment is penetrated, the total depth of the hole would be 1035 m. No Cretaceous rocks have ever been sampled on the STR. The site is in a local low in the Cretaceous surface and is believed to be safe as regards possible hydrocarbon entrapment.

West South Tasman Rise: WSTR2

This site is about 60 km east of Site WSTR1, on the western slope of the culmination of the South Tasman Rise, and is designed to penetrate a thicker (and older) early Neogene sequence (470 m compared to 185 m) than at that site. Unlike Site WSTR1, the young transparent ooze sequence is absent, but the underlying well-bedded sequence is well developed. This site too, has suffered continuous sinking since Oligocene breakup of Antarctica and the STR, so palaeo-water depths must be much less than the present water depth of 2730 m, and hence calcareous microfossils should generally be preserved. Thus, this site would give us a high-resolution carbonate-rich sequence on the Indian Ocean side of the STR, and about 500 km south of the west Tasmanian Neogene Site WT1. Like Site WSTR1, it lies close to the position of the present Sub-Tropical Convergence, and is well positioned to mark its movement through time.

It will help to more accurately date the Oligocene unconformity. The overyling sediments should display the effects of the development of the newly developed Circum-Antarctic Current, through variations in grainsize and composition. By comparison with Site WSTR1, further west, the lowest part of the Neogene section appears to be present here, so WSTR2 is a good site for examining the mid-Oligocene unconformity and the immediately overlying sediments. It is also a good site for charting the incoming of open marine conditions in the Eocene (as represented by calcareous plankton), and for the analysis of the early-rift deltaic sediments.

The proposed site is at the intersection of multichannel seismic profiles SO36B-58 and *Tasmante* 14 (Figs. 2, 12, 23 & 24). It is designed to penetrate 0.55 s (470 m) of late Oligocene to Miocene ooze and chalk above the Oligocene unconformity, and 0.1 s (110 m) of Eocene to early Oligocene chalk below the Oligocene unconformity, a total depth of 580 m. The site is in a local low in the Cretaceous surface and should be safe as regards possible hydrocarbon entrapment.

West South Tasman Rise: TFZ01 & TFZ02

These sites (located in Figs. 12 & 19) are designed to penetrate the marginal ridge of the westernmost South Tasman Rise, in order to address global tectonic questions related to the formation of transform continental margins. The ridge is the northern extension of the Tasman Fracture Zone that extends to the Antarctic margin. Dredging has shown it to consist of acid and basic plutonic rocks and metasediments, overlain by Cainozoic sequences that are sheared in places. To the west it drops away steeply (10-20°) about 2000 m to the virtually unsedimented Oligocene oceanic crust. It forms the upturned margin to a deep sedimentary basin to the east, rising hundreds of metres above the present sediment surface. The ridge lies on a transform fault that seafloor spreading anomalies indicate was actively intracontinental from the early Eocene to late Oligocene (43-28 Ma), and actively continental-oceanic from the late Oligocene to early Miocene (28-20 Ma).

The basin to the east is known to contain about 500 m of Neogene carbonates and somewhat more than 500 m of Palaeogene deltaic sediments. Seismic interpretation suggests it contains more than 1500 m of Cretaceous sediments in places. The seismic profiles SO-36B-61 & 62 (Figs. 19, 21 & 22), crossing the proposed sites, show that the Cretaceous and Palaeogene sequences are upturned toward the ridge, but clearly pass into structureless, deformed material about 20 km east of the ridge crest. The Neogene sequence, in contrast, onlaps and pinches out against the deformed sediments of the ridge. On profile SO-36B-62, basement can be seen rising from 6.6 s below the eastern edge of the ridge (and 2.0 s below the seabed), to 4.8 s in the western flank of the ridge (water depth in outcrop of 3450 m). The seismic profiles suggest that the Cretaceous and Palaeogene sections were deformed by the transform motion, but that the motion stopped before the mid-Oligocene unconformity developed, when the ridge may have been dry land.

Dredging at this location on the western flank of the ridge (147/DR17 & 18; Fig. 19) has shown that basement consists of relatively fresh microgabbro, and basalt altered to greenschist facies (Exon et al., 1995). Phenocrysts are plagioclase, pyroxene, biotite and ilmenite, and the groundmass is dominantly wispy plagioclase. Dr Tony Crawford of the University of Tasmania (pers. comm), on the basis of thin section examination, believes these are likely to be of Tertiary age, rather than Jurassic or Cambrian (other possibilities). A full suite of geochemical work is underway, but the evidence at this stage points to this body having been intruded in the late Eocene or early Oligocene, in response to transtension along the intracontinental transform fault. The overlying sediments include laminated to thinly bedded, greenish, deltaic silty sandstone and mudstone containing late Eocene dinocysts of glacial character.

The two sites planned for this area are designed to sample the entire section using rotary drilling (RCB) alone. The deepest, TFZ01, is located on the eastern side of the ridge in a water depth of 3100 m at the intersection of SO-36B-62 and *Tasmante* 9 (Figs. 12 & 19). It is designed to drill to 500 m, penetrating nearly 450 m of Palaeogene sediments and 50 m of Cretaceous sediments, all of which should be deformed by the transform motion. It could be advantageous to move it further upslope SW along SO-36B-62 to get deeper in the section, and this would need a *JOIDES Resolution* site survey to provide a suitable crossing line.

The shallower hole, TFZ02, would also need a short *JOIDES Resolution* site survey, and would be drilled on a suitable terrace on the western slope, in a water depth of about 3300 m and about 150 m above the basement outcrop. It would drill about 200 m, including 100 m of deformed Cretaceous sediment and 50 m of basic basement rocks. The average slope near TFZ02 is 15°, and we hope to find a flatter section with soft sediments indicated on the 3.5 kHz echosounder, to provide a suitable position to spud in.

These two sites would provide information on thermal history, uplift, intrusion, the styles of deformation, and subsidence along a transform margin, that would be complementary and additional to the information from ODP Leg 159, on the Ivory Coast Transform. They would help extend the global model for transform margins established there that involves continent-continent and continent-ocean motion. They would cover not only the thermal history from the passing of the spreading ridge by the site, but also the thermal history related to the earlier intrusion of the basic body (something not present on the Ivory Coast Transform).

East Tasman Plateau: ETP1

This site (location in Fig. 2) is designed to penetrate high-resolution carbonate-rich Neogene and late Palaeogene sequences at a latitude comparable to the sites west of Tasmania, but on the other side of the South Tasman Rise, and subject today to warm-water eddies from the East Australian Current. The sediments rest on continental or volcanic basement at 1.1 s (about 1150 m). There is little angular break apparent at the Oligocene unconformity, so it may be of short duration and hence very valuable for dating the break-through of the Circum-Antarctic Current. It is also a good site for charting the incoming of open marine conditions in the Eocene (as represented by calcareous plankton) and comparing the situation here with that west of the STR.

This site has subsided during the Cainozoic, so palaeo-water depths will be less than the present water depth of 2800 m, and hence calcareous microfossils should be well preserved. The site lies north of the position of the present Sub-Tropical Convergence.

The proposed site is on multichannel seismic profile *Tasmante* 3 but unfortunately there is as yet no crossing profile (Figs. 2 & 28). It was originally designed to penetrate 0.43 s (365 m) of Neogene ooze and chalk above the Oligocene unconformity, 0.2 s (220 m) of thickly bedded Eocene to early Oligocene ooze and chalk below the unconformity, and 0.48 s (530 m) of thinly bedded Eocene mudstone above basement (possibly Eocene sills or flows), into which the hole could be drilled 50 m, if time is available. The minimum depth would be 615 m, including all 250 m of late Eocene to early Oligocene open marine chalk, and this depth is assumed in the present plans.

The optimal hole would be 1200m deep and this site would then give the entire post-breakup history of the enigmatic ETP. The site is in a depression in the basement and should be safe as regards possible hydrocarbon entrapment.

9B. INDIVIDUAL SITE SUMMARIES: ALTERNATE SITES

West Tasmania: WT 2

This site is designed to fully penetrate a thick Palaeogene section of shallow marine mudstone that was less extensively cored (103 m) at DSDP Site 282, where it consisted of dark coloured, organic-rich late Eocene nannofossil bearing mudstone, believed to have been deposited in a deep basin with restricted circulation (Kennett, Houtz et al., 1973). In addition, two middle Eocene *Sonne* cores consisting of organic-rich, paralic, deltaic fossiliferous mudstone (SO36/22SL & 30KL: Hinz et al., 1995) were taken on seismic profile SO36B-48. By comparison with ODP Leg 159, on a similar transform margin off west Africa (ODP Leg 159 Scientific Party, 1995), there is a good chance that anoxic sediments will have accumulated in a silled basin on the margins of the opening Southern Ocean.

The proposed site is at the intersection of multichannel seismic profiles SO36B-48 and BMR 78/12 in water now 2920 m deep (Figs. 2, 15 & 16). It is designed to penetrate 0.3 s (255 m) of Neogene ooze above the Oligocene unconformity, and 0.5 s (550 m) of Palaeogene mudstone between the Oligocene unconformity and the Cretaceous-Tertiary boundary at 0.8 s (805 m). If 50 m of Late Cretaceous shallow marine sediment is penetrated, the total depth of the hole would be 855 m. The Palaeogene sequence is prograded, so is probably part of a shelf delta. Whether it is restricted to the Eocene or will contain a Paleocene sequence is unknown, and that presence or absence, along with the nature of the Cretaceous sequence will provide important information about the breakup history of this transform margin. No Cretaceous rocks have ever been sampled on the STR. The site is in a local low in the Cretaceous surface and is believed to be safe as regards possible hydrocarbon entrapment.

Central South Tasman Rise: STR1

This site is on the southern slope of the culmination of the South Tasman Rise, and lies about 20 km north-northeast of DSDP Site 281, which was drilled on a basement high and is tied through seismic profile SO36B-51. At the proposed site, basement is at about 1.3 seconds (1500 m) and there is a thick wedge of Cainozoic and possibly older sediments. This site too has undergone continuous sinking since the Oligocene breakup of Antarctica and the STR, so palaeo-water depths must be much less than the present water depth of 1460 m, and hence calcareous microfossils should always be preserved. The site will provide a high-resolution carbonate-rich sequence on the ridge between the Indian and Pacific Oceans, and about 150 km east-southeast of the west STR Site WSTR2. It lies close to the position of the present Sub-Tropical Convergence, and 40 km south of WSTR2, so is complementary in tracking the convergence's movement through time.

This site is designed to penetrate about 200 m of Neogene section (60 m more than in DSDP 281), and a thick Palaeogene section of shallow marine mudstone. *Sonne* coring and *Rig Seismic* dredging, and DSDP Site 281, suggest that the facies is greatly different to that on the Tasmanian margin (DSDP 282, *Sonne* cores and WT2 proposal). On the South Tasman Rise, the facies is of grayish olive to greenish gray late Eocene shelf to upper slope mudstone, with abundant microfossils in places, most of them siliceous. The dredges, from the western margin of the SouthTasman Rise, contain late Eocene dinocysts of Antarctic character.

The Palaeogene sequence consists of two parts: a hummocky well-bedded upper part, and a less well-bedded lower part prograded to the south, that onlaps possible Late Cretaceous sediments and is probably part of a shelf delta. The upper part toplaps the lower part. Complete coring of this sequence would document climatic variations in the Palaeogene, near the Antarctic margin. Whether it is restricted to the Eocene or will contain a Paleocene sequence is unknown, and that presence or absence, along with the nature of the Cretaceous sequence, will provide important information about the breakup history of this transform margin. The site is in a structural low over shallow basement, and furthermore there was no problem with hydrocarbons in DSDP 281 on a nearby structural high, so there is no danger of hydrocarbon entrapment.

The proposed site is at the intersection of multichannel seismic profiles *Tasmante* 31 and SO-38B-51 (Figs. 2, 7, 8, 25 & 26). It is designed to penetrate 0.21 s (180 m) of Neogene ooze and chalk above the Oligocene unconformity, 0.32s (350 m) of late Eocene to early Oligocene marls below the Oligocene unconformity, and 0.53 s (580 m) of older Palaeogene mudstone. The presumed Cretaceous-Tertiary boundary lies at 1.06 s (1110 m), and penetrating an additional 50 m of Late Cretaceous shallow marine sediments would result in a total depth of 1160 m.

Depression off Southeast Tasmania: SET1

This is a Neogene site in an oceanic depression southeast of Tasmania and between the South Tasman Rise and the East Tasman Plateau. It is of great interest because it contains a large sediment drift, derived by currents sweeping the South Tasman Rise, and high depositional rates should allow the preservation of a high-resolution Cainozoic calcareous record. At the proposed site in 4055 m of water, basement is at about 1.4 seconds (1600 m) and its age is uncertain. This site has continuously sunk since basement formed, probably in the Palaeogene, so palaeo-water depths may be less than the present water depth, permitting the preservation of calcareous microfossils. The site will provide a fossiliferous sequence east of the ridge between the Indian and Pacific Oceans, and an interesting comparison with the more westerly sites. It lies close to the position of the present Sub-Tropical Convergence, so would help in tracking the convergence's movement through time.

This site is designed to penetrate about 400 m of Neogene section, and 100 m into unconformably underlying Palaeogene sediments. The Neogene sequence consists of two parts: a well-bedded, thick-bedded, almost planar-bedded, upper part, and a hummocky, thinner bedded lower part. The upper part onlaps the lower, and the lower part fills hummocks in the underlying thinly bedded Palaeogene sequence. The site overlies oceanic crust, so there is no potential problem with hydrocarbon entrapment. The facies should have been laid down in very different conditions to those in shallow water to the west. The Palaeogene sequence might be similar to the late Eocene and early Oligocene silty diatom ooze with some nannofossils, found in the deepwater DSDP Site 280 to the south and the abyssal plain Site 283 to the east, but it should be more calcareous.

The proposed site is on multichannel seismic profile *Tasmante* 4, and unfortunately there is no crossing profile (Figs. 2, 7 & 27). It is designed to penetrate 0.2 s (170 m) of thick bedded Neogene ooze and 0.27 s (230 m) of thin-bedded ooze and chalk above the Oligocene unconformity, and 100 m of older late Eocene to early Oligocene ooze. Total depth would be 500 m.

10. SITE SURVEY REQUIREMENTS

A large open file database (Section 4) includes swath-mapping (bathymetry and imagery) of all sites and most of the region of interest, and crossing multichannel seismic profiles and echosounder profiles across all but three sites (TFZ02, SET1 & ETP1). There are also extensive satellite and shipboard gravity data sets, and a shipboard magnetometer data set. Extensive dredging and coring has been carried out on seismic profiles to ground-truth their interpretation. Interpretive work is continuing.

The combination of the above information with that from DSDP Sites 281 and 282 has enabled us to select sites with care. We suggest that there is no need for further pre-cruise site surveys at these deepwater locations, but believe that short *JOIDES Resolution* profiles normal to the existing profile across ETP1 would be valuable, and that a brief survey to find optimal locations for TFZ01 & TFZ02 should be programmed.

11. SITE SAFETY

The four different areas - west Tasmania, South Tasman Rise, East Tasman Plateau, and the oceanic depression between the latter two - are quite different in terms of potential site safety. West Tasmania, and to a lesser extent the South Tasman Rise, have potential safety problems in terms of possible hydrocarbon accumulations, but we believe these can be overcome.

West Tasmanian margin

This is part of the thick sedimentary section of the Sorell Basin. Organic-rich late Eocene silty clays at DSDP Site 282 west of Tasmania have petroleum source rock potential (Hunt, 1975). On the continental shelf, in Cape Sorell No.1 exploration well, extensive traces of oil were found in the latest Cretaceous/earliest Paleocene. A shipboard study of 27 *Sonne* cores (Whiticar & others, 1985) indicated that wet gas of thermogenic origin is abundant in surface sediments on the upper slope and shelf, indicating the presence of mature source rocks. This suggests that even in the deep-water areas, sites should be located with caution, even though no suitable reservoir rocks are known from deep-water sampling of Cretaceous and Cainozoic rocks, or from the Cainozoic sequence of DSDP Site 282. Site 282 was drilled on a major structural high and had no shows of more than background gas. The two sites proposed for the margin are WT1 and WT2.

Site *WT1* is designed to penetrate through a thick Cainozoic sequence into the uppermost Cretaceous. It is in an area without any structuring, where Cainozoic sequences dip toward the ocean, and Cretaceous sequences toward Tasmania, so that any hydrocarbons could migrate freely out of the area. The evidence from DSDP Site 282 suggests that the Palaeogene sequence is mud-dominated, but the seismic profiles suggest a deltaic origin, with the possibility of some porous beds, in both the Palaeogene and the Cretaceous. Total sediment thickness nearby is unlikely to exceed 1500 m, and the site is believed to be safe.

Site *WT2* is an alternate site designed to penetrate into the uppermost Cretaceous on a structural low in an area of thick, very gently dipping sediments (>2500 m). As with Site WT1, the evidence from DSDP Site 282 suggests that the Palaeogene sequence is mud-dominated, but the seismic profiles suggest a deltaic origin, with the possibility of some porous beds, in both the Palaeogene and the Cretaceous. The seismic profiles also suggest that the prograding in both sequences is toward the southwest, and that the drainage of any hydrocarbons would be toward Tasmania. The site is probably safe, but continuous gas analysis would be essential if it were drilled.

South Tasman Rise

Fourteen surface cores were analysed for gases on the South Tasman Rise and most were poor in hydrocarbons (Whiticar et al., 1995) although three stations in the northeast (well away from the proposed sites) gave moderate yields with a thermogenic signature. No source beds were identified in DSDP Site 281. The rise is complex, with areas of shallow basement and some deeper basins.

Site *WSTR1* is designed to penetrate into the uppermost Cretaceous in a gentle structural low in an area of thick, almost flat-lying sediments (> 2500 m). The evidence from DSDP Site 281 suggests that the Palaeogene sequence is mud-dominated, but the seismic profiles suggest a deltaic origin, with the possibility of some porous beds, in the Palaeogene. The seismic profiles also suggest that the prograding is toward the southeast, and that the drainage of any hydrocarbons would be toward the northwest. The site is believed to be safe, but continuous gas analysis would be essential during drilling.

Site *WSTR2* is essentially a Neogene ooze site, so is most unlikely to contain any potential reservoir rocks. It is located in an area of flat-lying Cainozoic sediments, overlying a structural low in the Cretaceous sequences. The Palaeogene sequence does contain some bedding, but little evidence of prograding. Although total sediment thickness nearby may reach 3000 m, the site is believed to be safe.

Alternate site *STR1* is designed to penetrate into the uppermost Cretaceous in an area where maximum sediment thickness is about 2500 m. The site is on a basement slope that rises southwest to the high drilled at DSDP Site 281 about 15 km away, while the Cainozoic sediments dip south. This configuration means that there is little chance of up-dip pinchouts. The evidence from DSDP Site 281 suggests that the Palaeogene sequence is mud-dominated, but the seismic profiles suggest a deltaic origin, with some possibility of porous beds. The seismic profiles also suggest that the prograding is toward the south, and that the drainage of any hydrocarbons would be toward the north. The site is probably safe, but continuous gas analysis would be essential if it were drilled.

Sites *TFZ01* & *TFZ02* are relatively shallow sites to be drilled into the sheared ridge flanking the western margin of the STR (Figs. 19-22), and fairly comparable to the ridge site 960 drilled on Leg 159. Two of the arguments presented to and accepted by the Pollution Prevention and Safety Panel for Leg 159 also apply here. They are that the depth of burial will not exceed 600 m; and that the structural history is complex and fracturing should have assisted fluid escape. Any hydrocarbons that might be moving updip to the west, and managing to enter the shear zone, should readily vent into the sea above and to the west of the ridge.

Oceanic depression between South Tasman Rise and East Tasman Plateau

Site *SET1* is essentially a Neogene ooze site, so is most unlikely to contain any potential reservoir rocks. It is located in an area of flat-lying Cainozoic sediments 1500-1700 m thick, overlying oceanic crust of probable early Tertiary age. The Palaeogene sequence does contain some bedding, but little evidence of prograding. Given the sediment thickness there is little chance of hydrocarbon generation, and there are no conceivable traps, so the site is believed to be safe.

East Tasman Plateau

This little known plateau has recently been proved to be continental by the dredging of granite, metamorphic rocks, acid volcanics and quartz-rich sediments on AGSO Cruise 147. The few seismic profiles across the plateau suggest that basement is universally shallow, and nowhere deeper than 1500-1770 m.

Site *ETP1* in its optimal form is designed to penetrate through Cainozoic sediments into basement in a gentle structural low in an area of almost flat-lying sediments about 1100 m thick. The seismic profile suggests that there is a Neogene pelagic carbonate sequence overlying a muddy Palaeogene sequence. Given the sediment thickness, there is almost no chance of hydrocarbon generation, and there are no conceivable traps, so the site is believed to be safe.

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13. INDIVIDUAL ODP SITE SUMMARY FORMS AND RELEVANT SEISMIC SECTIONS

Note that the symbols on the seismic sections are: O = Oligocene unconformity, C = top Cretaceous, C2 = top Lower Cretaceous, B = basement

ODP Site Summary Form6/93 Fill out one form for each proposed site and attach to proposal

Title of Proposal:	**The "southern gateway" between Australia and Antarctica: a proposal for ODP palaeoclimatic, palaeoceanographic and tectonic drilling**
Site-specific Objective(s) (List of general objectives must be inc. in proposal)	A. Fully penetrate Neogene pelagic carbonate sequence (ca. 680 m) to give high-resolution biostratigraphy on the Indian Ocean side of the South Tasman Rise, for comparison with sites further south (WSTR 1 & 2) that have been influenced by movements of the Sub-Tropical Convergence, and further east on the Pacific Ocean side of the STR (SET1 &. ETP 1) B. Date age of Oligocene unconformity by penetrating underlying sequence. C. Fully penetrate Paleogene deltaic mudstone sequence (ca. 400 m) to give comparison with other sites further south, and thus to build history of marine transgression related to rifting.

	Proposed Site	Alternate Site
Site Name:	WT1	
Area:	west Tasmanian margin	
Lat./Long.:	42°37'S, 144°24.5'E	
Water Depth:	2500 m	
Sed. Thickness:	1400 m	
Total penetration:	1245 m	

	Sediments	Basement
Penetration:	1225 m	20 m
Lithology(ies):	0-680 m = Neogene ooze and chalk 680-1120 m = late Eocene mudstone 1120-1225 m = Late Cretaceous mudstone	1225-1245 continental basement
Coring (check):	1-2-3-APC✓ VPC* XCB✓ MDCB* PCS RCB✓ DCS* Re-entry✓	
Downhole measurements:		

*Systems currently under development

Target(s) :(see Appendix of Proposal Submission Guidelines6/93) A✓ B✓ C D E F G (check)ß

Site Survey Information (see Appendix of Proposal Submission Guidelines6/93 for details and requirements):

		Check	Details of data available and data still to be collected
01	SCS deep penetration	✓	
02	SCS High Resolution	✓	
03	MCS and velocity	✓	*l'Atalante* 6 channel, *Sonne* 24 channel
04	Seismic grid		Crossing tracks
05	Refraction		
06	3.5 or 12 kHz	✓	
07	Swath bathymetry	✓	Simrad EM12D swath-mapping by *l'Atalante*
08	H.-res side-looking sonar	✓	
09	Photography/video		
10	Heat flow		
11	Magnetics/gravity	✓	*l'Atalante, Sonne*
12	Coring	✓	Nearby (Fig 10)
13	Rock sampling	✓	On scarp to west (Fig. 10)
14	Current meter	✓	
15	Other		

Weather, Ice, Surface Currents: Can have rough weather in southern winter

Territorial Jurisdiction: Australian

	Name/Address	Phone/FAX/Email
Contact Proponent:	Dr Neville Exon, Australian Geological Survey Organisation, PO Box 378, Canberra, Australia 2601	Ph: +61 6 2499347 Fax: + 61 6 2499980 Email: nexon@agso.gov.au

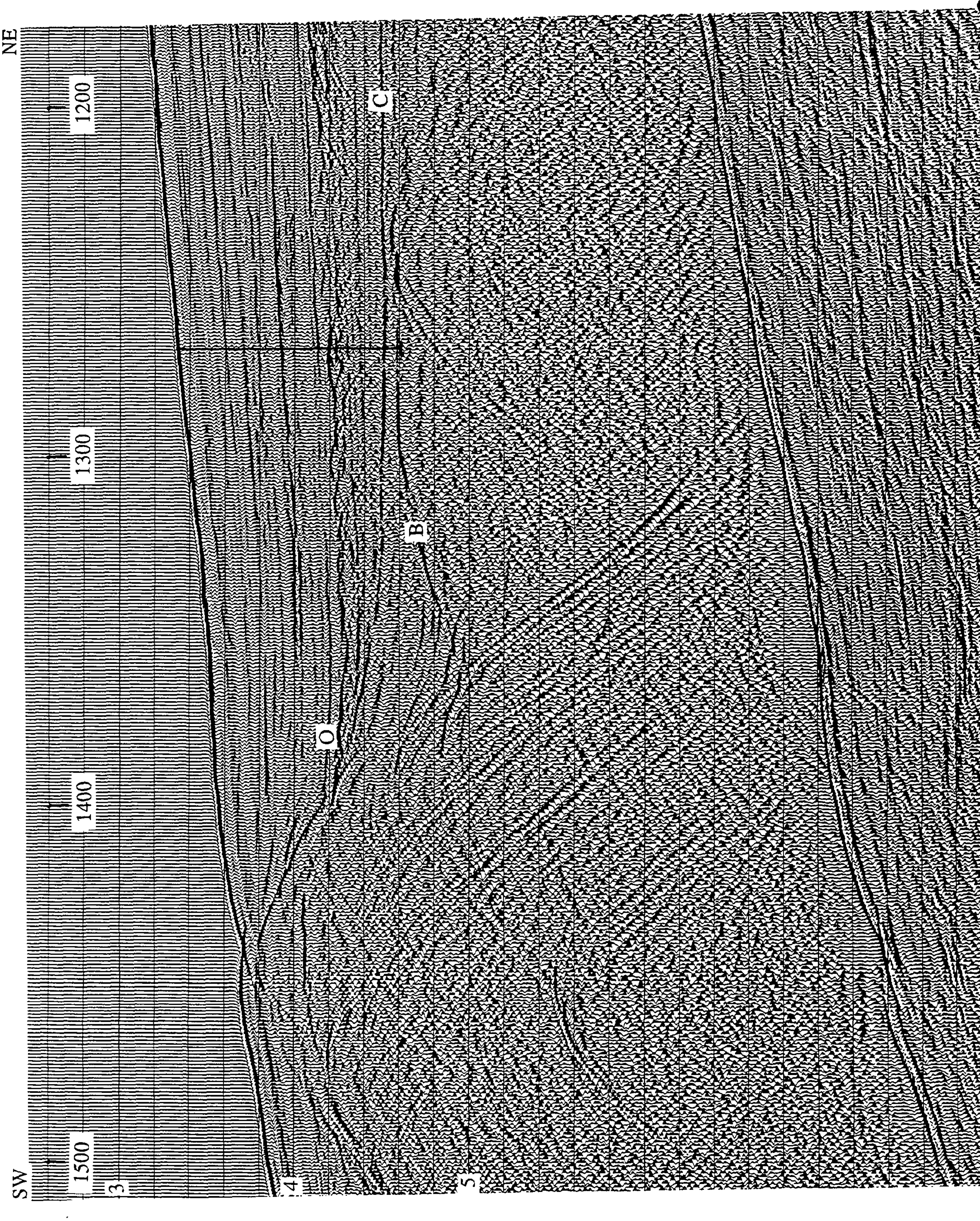


Figure 13. Location of proposed site WT1 on *Sonne* seismic profile SO36B-47; ties *Tasmante* seismic profile 52 at site.

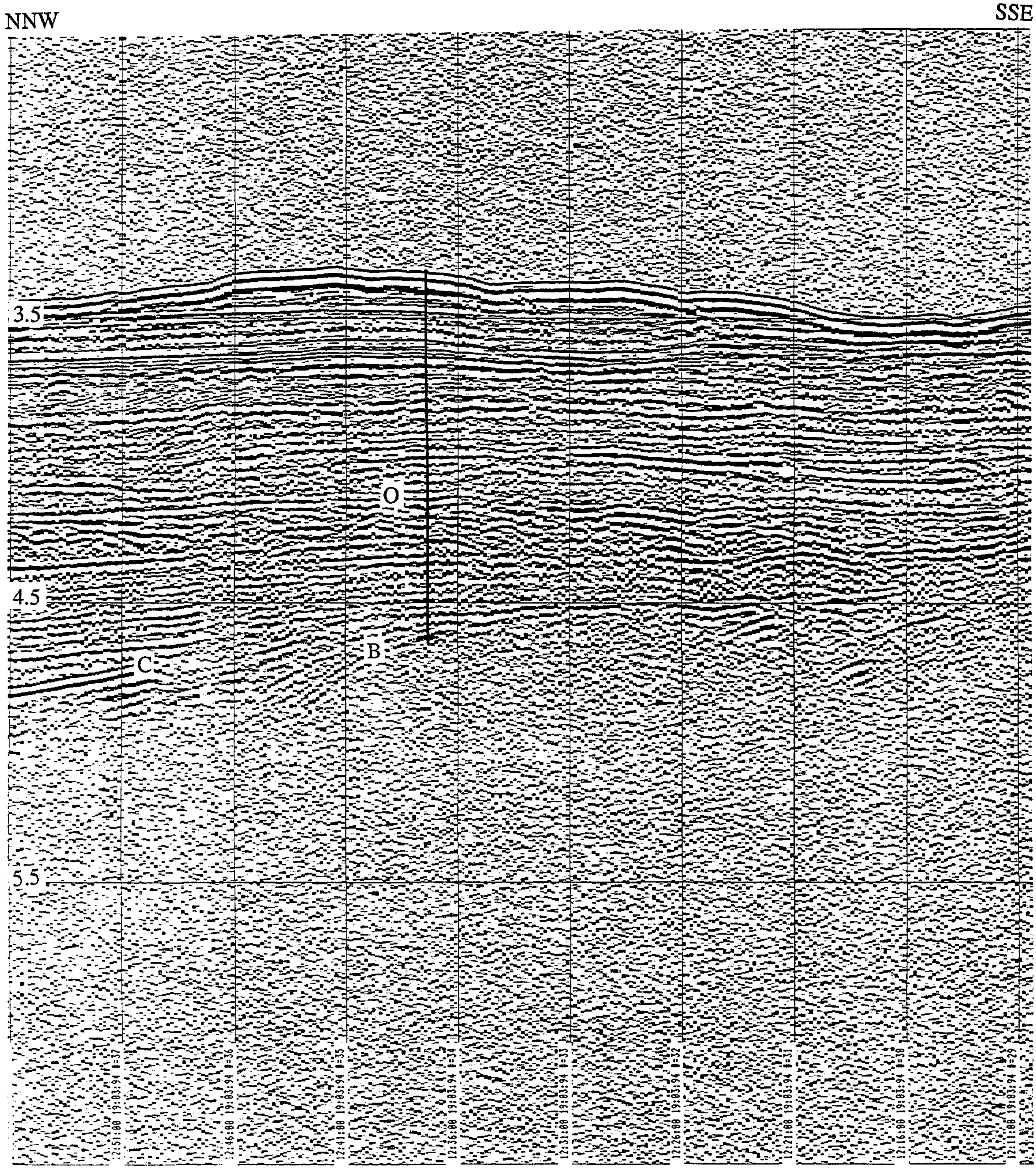


Figure 14. Location of proposed site WT1 on *Tasmante* line 52; ties *Sonne* seismic profile SO36B-47 at site.

ODP Site Summary Form6/93 Fill out one form for each proposed site and attach to proposal

Title of Proposal:	**The "southern gateway" between Australia and Antarctica: a proposal for ODP palaeoclimatic, palaeoceanographic and tectonic drilling**
Site-specific Objective(s) (List of general objectives must be inc. in proposal)	A. Fully penetrate calcareous Palaeogene marine mudstone (ca. 550 m) to give high-resolution biostratigraphy on the Indian Ocean side of the STR for comparison with siliceous sites further south (WSTR 1 & STR2, and east on the Pacific Ocean side (ETP1). B. By penetrating underlying Cretaceous sequence, date K/T unconformity and establish nature of Cretaceous deposition.

	Proposed Site	Alternate Site
Site Name:	WT2	
Area:	west Tasmanian margin	
Lat./Long.:	43°43.5'S, 145°02'E	
Water Depth:	2920 m	
Sed. Thickness:	>2500 m	
Total penetration:	855 m	

	Sediments	Basement
Penetration:	855 m	0 m
Lithology(ies):	0-255 m = Neogene ooze; 255-805 m = late Eocene mudstone; 50 m Cretaceous	
Coring (check):	1-2-3-APC✓ VPC* XCB✓ MDCB* PCS RCB✓ DCS* Re-entry	
Downhole measurements:		

*Systems currently under development

Target(s) :(see Appendix of Proposal Submission Guidelines6/93) A✓ B✓ C D E F G (check)ß

Site Survey Information (see Appendix of Proposal Submission Guidelines6/93 for details and requirements):

		Check	Details of data available and data still to be collected
01	SCS deep penetration	✓	
02	SCS High Resolution	✓	
03	MCS and velocity	✓	*Rig Seismic* 24 channel, *Sonne* 24 channel
04	Seismic grid		Crossing tracks
05	Refraction		
06	3.5 or 12 kHz		
07	Swath bathymetry	✓	Simrad EM12D swath-mapping by *l'Atalante*
08	H.-res side-looking sonar	✓	
09	Photography/video		
10	Heat flow		
11	Magnetics/gravity	✓	*l'Atalante, Sonne*
12	Coring	✓	Nearby (Fig. 10)
13	Rock sampling	✓	On scarp to west (Fig. 10)
14	Current meter	✓	
15	Other		

Weather, Ice, Surface Currents: Can have rough weather in southern winter

Territorial Jurisdiction: Australian

	Name/Address	Phone/FAX/Email
Contact Proponent:	Dr Neville Exon, Australian Geological Survey Organisation, PO Box 378, Canberra, Australia 2601	Ph: +61 6 2499347 Fax: + 61 6 2499980 Email: nexon@agso.gov.au

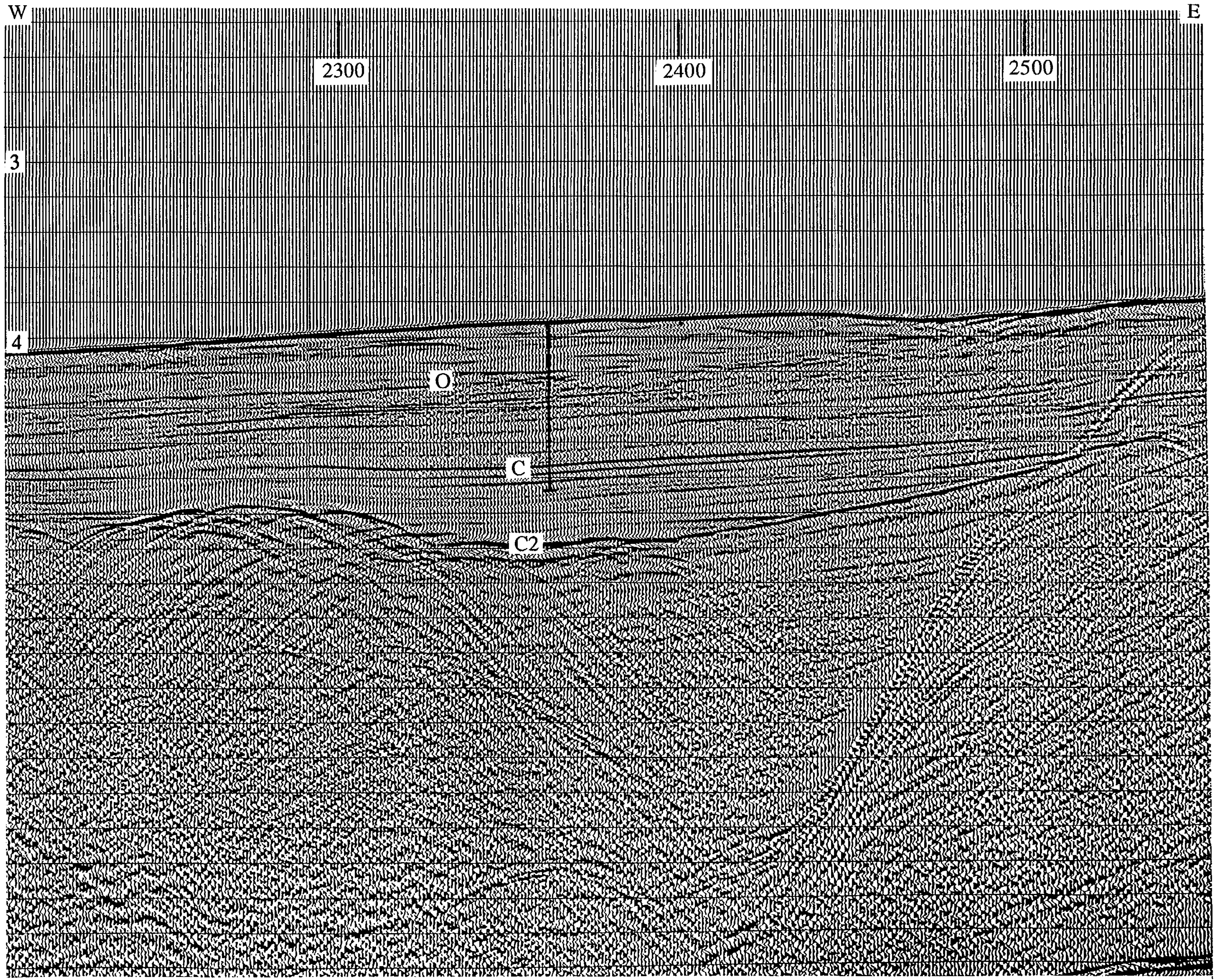


Figure 15. Location of proposed site WT2 on *Sonne* seismic profile SO36B-48; ties BMR seismic profile 78/12 at site.

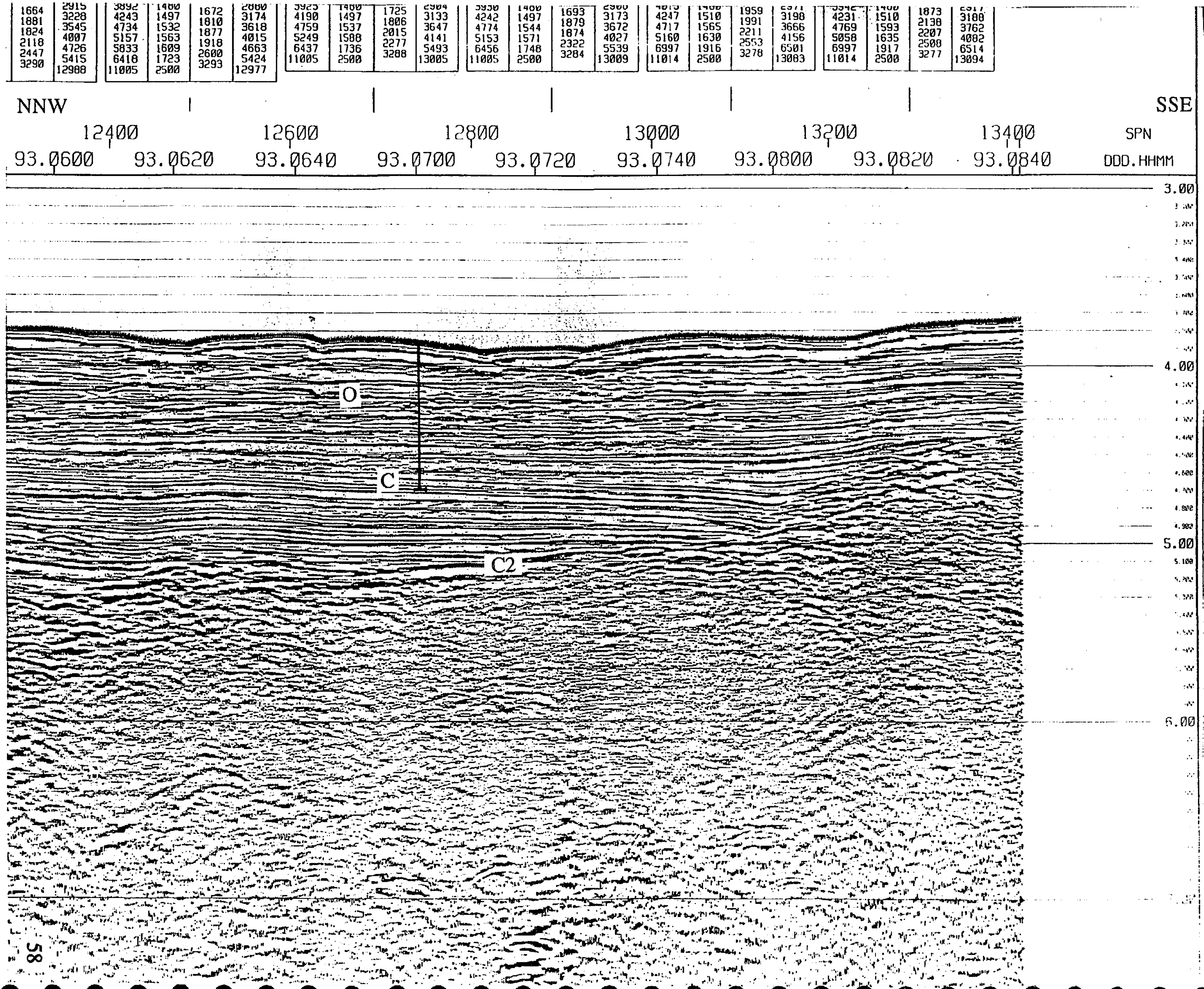


Figure 16. Location of proposed site WT2 on BMR seismic profile 78/12; ties *Sonne* seismic profile SO36B-48 at site.

ODP Site Summary Form6/93 Fill out one form for each proposed site and attach to proposal

Title of Proposal:	**The "southern gateway" between Australia and Antarctica: a proposal for ODP palaeoclimatic, palaeoceanographic and tectonic drilling**
Site-specific Objective(s) (List of general objectives must be inc. in proposal)	A. Fully penetrate Neogene pelagic carbonate sequence (ca. 380 m),, and especially Pliocene to Recent sequence, (ca. 195 m) to give high-resolution biostratigraphy on Indian Ocean side of STR, for comparison with sites in other palaeogeographic positions (WT1, WSTR2, ETP1). B. Date age of Oligocene unconformity by penetrating underlying sequence. C. Fully penetrate Eocene to early Oligocene chalk to give high-resolution biostratigraphy on the Indian Ocean side of STR for comparison with calcareous sites further north (WT1), and east on the Pacific Ocean side (ETP 1). Fully penetrate siliceous Palaeogene marine mudstone (ca. 495 m) for comparison with sites to north and east. D. By penetrating Cretaceous sequence, date K/T unconformity and establish nature of deposition

	Proposed Site	Alternate Site
Site Name:	WSTR1	
Area:	western South Tasman Rise	
Lat./Long.:	47°03'S, 145°15'E	
Water Depth:	3570 m	
Sed. Thickness:	>2500 m	
Total penetration:	1035 m	

	Sediments	Basement
Penetration:	1035 m	0 m
Lithology(ies):	0-195 m = Pliocene-Recent ooze; 195-380 m = late Oligocene to Miocene ooze and chalk; 380-490 m = Eocen to early Oligocene chalk; 490-985 m = Paleaogene mudstone; 985-1035 Cretaceous sediments	
Coring (check):	1-2-3-APC ✓ VPC* XCB ✓ MDCB* PCS RCB ✓ DCS* Re-entry ✓	
Downhole measurements:		

*Systems currently under development

Target(s) :(see Appendix of Proposal Submission Guidelines6/93) A ✓ B ✓ C D E F G (check)ß

Site Survey Information (see Appendix of Proposal Submission Guidelines6/93 for details and requirements):

		Check	Details of data available and data still to be collected
01	SCS deep penetration	✓	
02	SCS High Resolution		
03	MCS and velocity	✓	*l'Atalante* 6 channel
04	Seismic grid		Crossing tracks
05	Refraction		
06	3.5 or 12 kHz	✓	
07	Swath bathymetry	✓	Simrad EM12D swath-mapping by *l'Atalante*
08	H.-res side-looking sonar	✓	
09	Photography/video		
10	Heat flow		
11	Magnetics/gravity	✓	*l'Atalante, Sonne*
12	Coring	✓	Nearby (Fig. 11)
13	Rock sampling	✓	On scarp to west (Fig. 11)
14	Current meter		
15	Other		

Weather, Ice, Surface Currents: Can have rough weather in southern winter. Territorial Jurisdiction: Australian

	Name/Address	Phone/FAX/Email
Contact Proponent:	Dr Neville Exon, Australian Geological Survey Organisation, PO Box 378, Canberra, Australia 2601	Ph: +61 6 2499347 Fax: + 61 6 2499980 Email: nexon@agso.gov.au

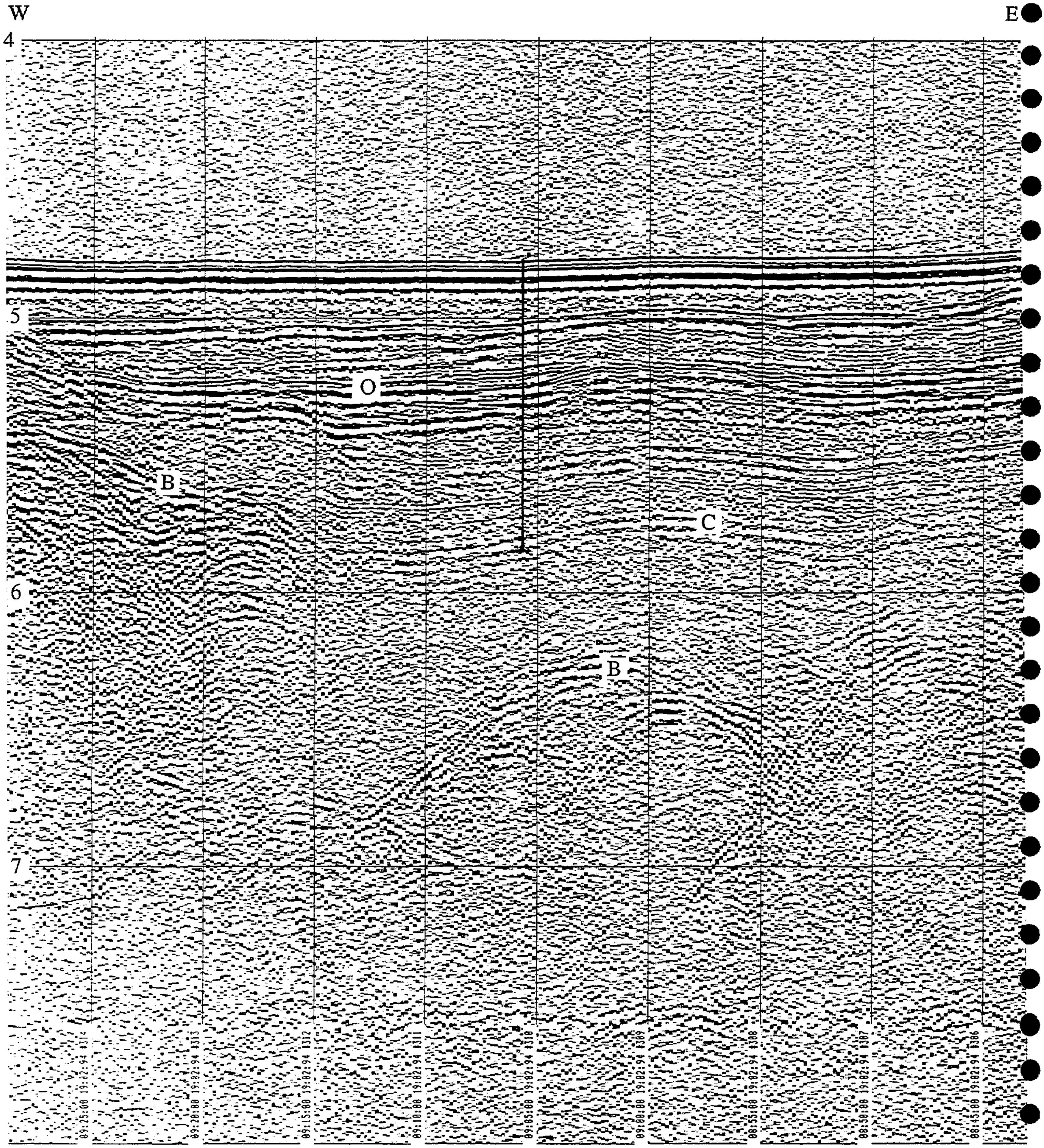


Figure 17. Location of proposed site WSTR1 on *Tasmante* seismic profile 4; ties *Tasmante* seismic profile 9 at site.

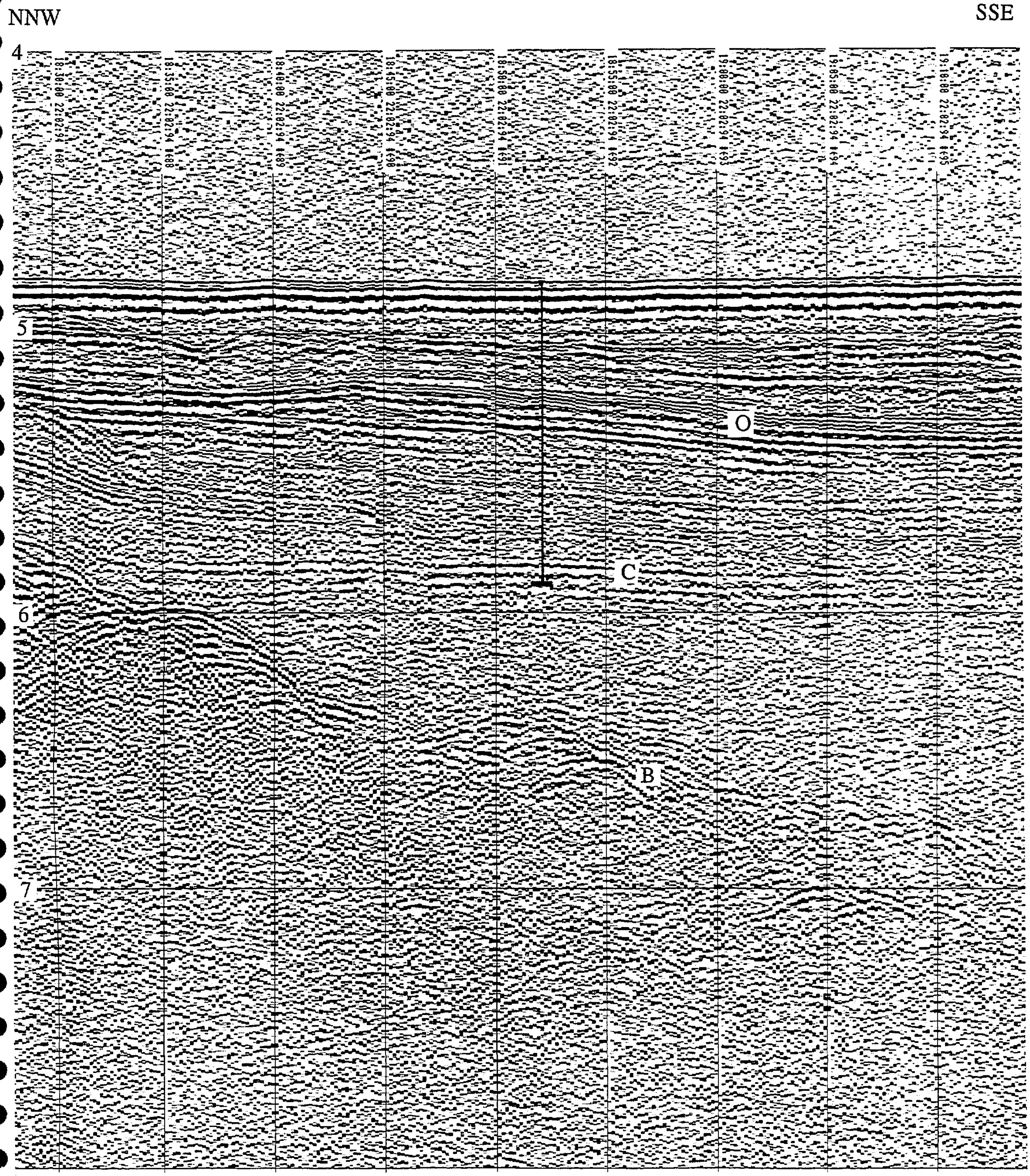


Figure 18. Location of proposed site WSTR1 on *Tasmante* seismic profile 9; ties *Tasmante* seismic profile 4 at site.

ODP Site Summary Form6/93 Fill out one form for each proposed site and attach to proposal

Title of Proposal:	**The "southern gateway" between Australia and Antarctica: a proposal for ODP palaeoclimatic, palaeceanographic and tectonic drilling**
Site-specific Objective(s) (List of general objectives must be inc. in proposal)	A. Fully penetrate 450 m of tectonically deformed sequence of Palaeogene mudstone and sandstone above transform ridge forming western margin of STR, in order to examine tectonic fabric and its relationship to Early Tertiary fault motion. B. Penetrate 50 m of tectonically deformed sequence of Late Cretaceous mudstone and sandstone above transform ridge forming western margin of STR, in order to examine tectonic fabric and its relationship to Early Tertiary fault motion..

	Proposed Site	Alternate Site
Site Name:	**TFZ01**	
Area:	west South Tasman Rise	
Lat./Long.:	46°47.5'S, 145°03.2'E	
Water Depth:	3100 m	
Sed. Thickness:	ca. 3000 m	
Total penetration:	500 m	

	Sediments	Basement
Penetration:	500 m	0 m
Lithology(ies):	0-450 m = Palaeogene mudstone 450-500 m = Late Cretaceous mudstone	
Coring (check):	1-2-3-APC VPC* XCB MDCB* PCS RCB ✓ DCS* Re-entry	
Downhole measurements:		

*Systems currently under development

Target(s) :(see Appendix of Proposal Submission Guidelines6/93) A B C ✓ D E F G (check)ß

Site Survey Information (see Appendix of Proposal Submission Guidelines6/93 for details and requirements):

		Check	Details of data available and data still to be collected
01	SCS deep penetration	✓	
02	SCS High Resolution	✓	
03	MCS and velocity	✓	*l'Atalante* 6 channel, *Sonne* 24 channel
04	Seismic grid		Crossing tracks
05	Refraction		
06	3.5 or 12 kHz	✓	
07	Swath bathymetry	✓	Simrad EM12D swath-mapping by *l'Atalante*
08	H.-res side-looking sonar	✓	
09	Photography/video		
10	Heat flow		
11	Magnetics/gravity	✓	*l'Atalante, Sonne*
12	Coring	✓	Nearby (Fig. 11)
13	Rock sampling	✓	On scarp just to west (Fig. 11)
14	Current meter	✓	
15	Other		

Weather, Ice, Surface Currents: Can have rough weather in southern winter

Territorial Jurisdiction: Australian

	Name/Address	Phone/FAX/Email
Contact Proponent:	Dr Neville Exon, Australian Geological Survey Organisation, PO Box 378, Canberra, Australia 2601	Ph: +61 6 2499347 Fax: + 61 6 2499980 Email: nexon@agso.gov.au

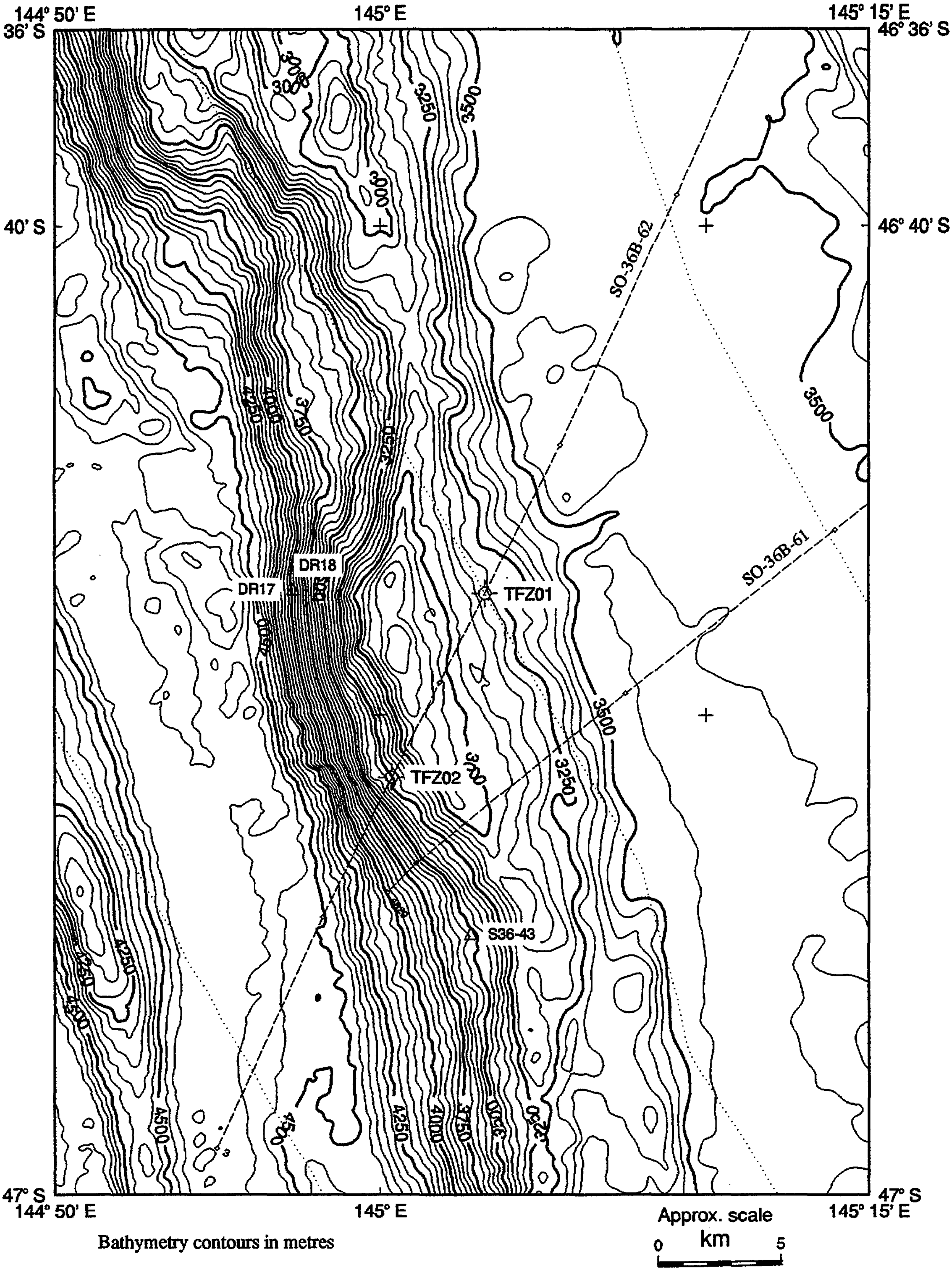


Figure 19. Bathymetric map prepared from *Tasmante* swath-mapping data showing location of tectonic sites TFZ01/02 on marginal ridge on westernmost STR. TFZ02 is on a slight terrace with a 10° slope. Also shows nearby dredge locations. Whether adequate soft sediment lies on the Palaeogene sediments here will be checked with the Bundesanstalt für Geowissenschaften und Rohstoffe, which holds the 3.5 kHz data.

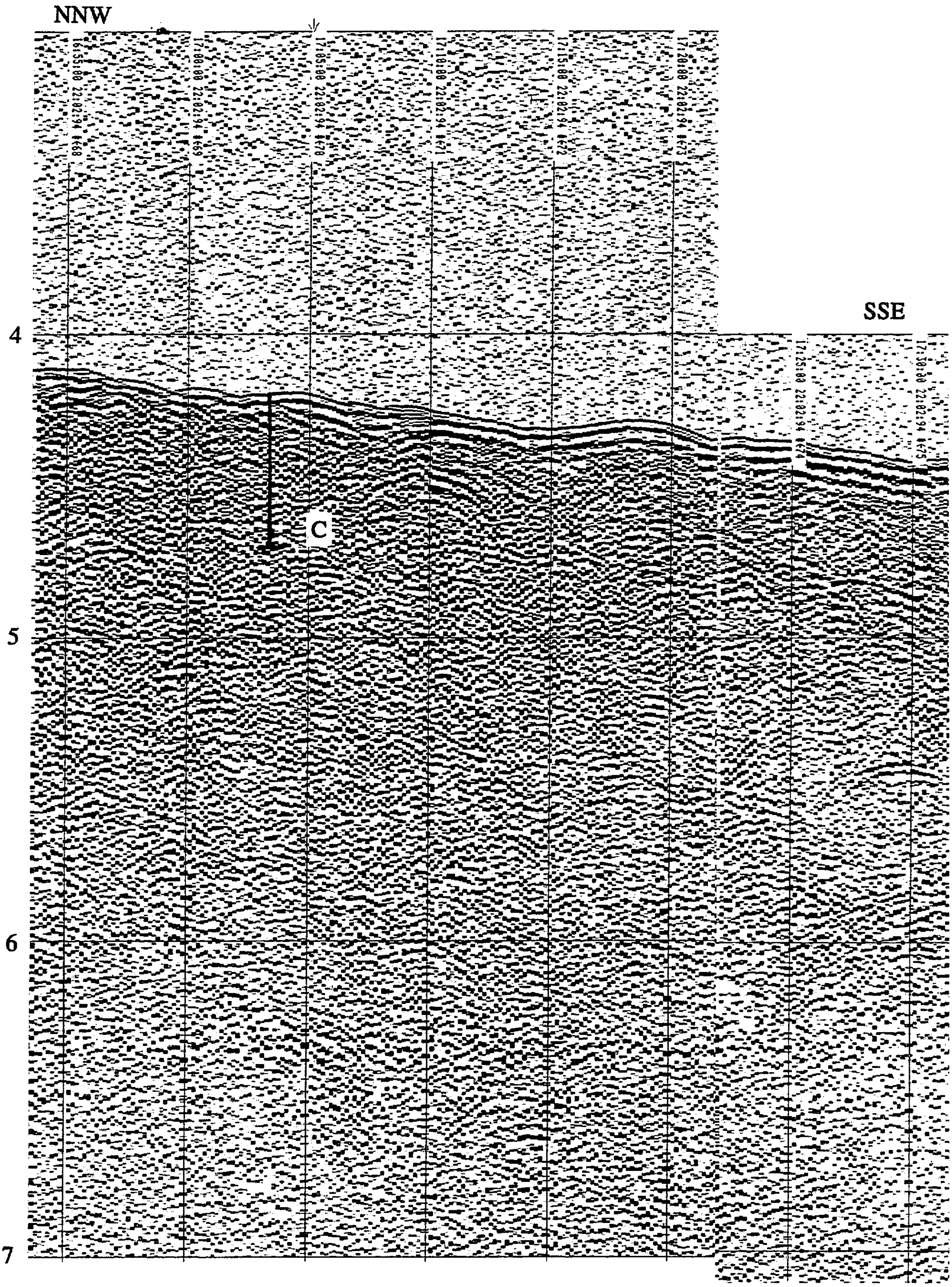


Figure 20. Location of proposed site TFZ01 on *Tasmante* seismic profile 9; ties *Sonne* seismic profile SO36B-62 at site.

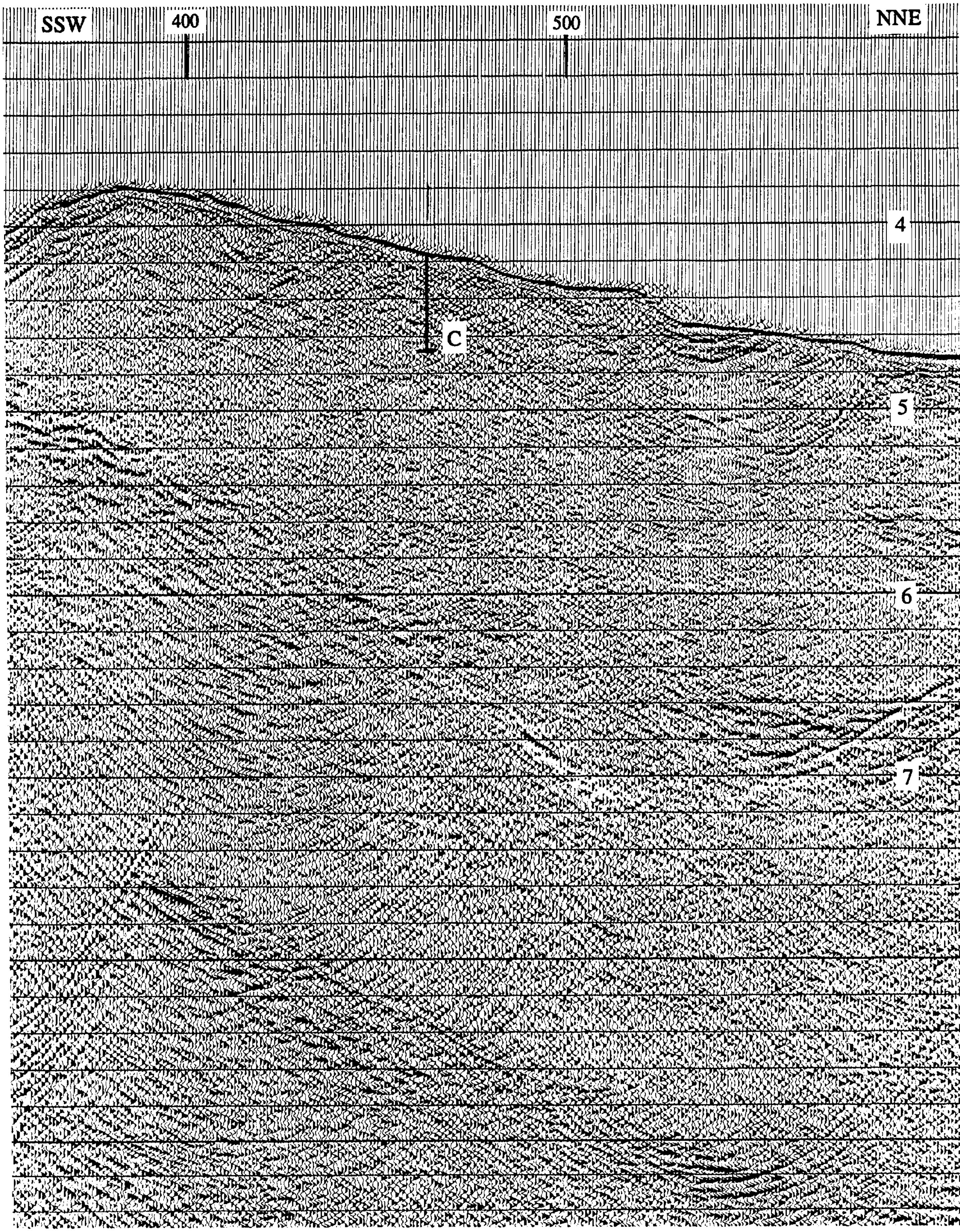


Figure 21. Location of proposed site TFZ01 on *Sonne* seismic profile SO36B-62; ties *Tasmante* seismic profile 9 at site.

ODP Site Summary Form6/93 Fill out one form for each proposed site and attach to proposal

Title of Proposal:	**The "southern gateway" between Australia and Antarctica: a proposal for ODP palaeoclimatic, palaeceanographic and tectonic drilling**
Site-specific Objective(s) (List of general objectives must be inc. in proposal)	A. Penetrate 50 m of tectonically deformed sequence of Palaeogene mudstone and sandstone above transform ridge forming western margin of STR, in order to examine tectonic fabric and its relationship to Early Tertiary fault motion. B. Penetrate 100 m of tectonically deformed sequence of Late Cretaceous mudstone and sandstone above transform ridge,in order to examine tectonic fabric and its relationship to Early Tertiary fault motion.. E. Penetrate 50 m of basic intrusive body forming basement in the transform ridge to detail the nature and age of such an intrusion for the first time globally.

	Proposed Site	Alternate Site
Site Name:	TFZ02	
Area:	west South Tasman Rise	
Lat./Long.:	46°51.3'S, 145°00.35'E	
Water Depth:	3200 m	
Sed. Thickness:	ca. 3000 m	
Total penetration:	200 m	

	Sediments	Basement
Penetration:	150 m	50 m
Lithology(ies):	0-50 m = Palaeogene mudstone 50-150 m = Late Cretaceous mudstone	Basic continental intrusion

Coring (check): 1-2-3-APC VPC* XCB MDCB* PCS RCB✓ DCS* Re-entry

Downhole measurements:

*Systems currently under development

Target(s) :(see Appendix of Proposal Submission Guidelines6/93) A B C D E F G ✓ (check)ß

Site Survey Information (see Appendix of Proposal Submission Guidelines6/93 for details and requirements):

		Check	Details of data available and data still to be collected
01	SCS deep penetration	✓	
02	SCS High Resolution		
03	MCS and velocity	✓	*Sonne* 24 channel
04	Seismic grid		No crossing tracks at this stage
05	Refraction		
06	3.5 or 12 kHz	✓	
07	Swath bathymetry	✓	Simrad EM12D swath-mapping by *l'Atalante*
08	H.-res side-looking sonar	✓	
09	Photography/video		
10	Heat flow		
11	Magnetics/gravity	✓	*Sonne*
12	Coring	✓	Nearby (Fig. 11)
13	Rock sampling	✓	On scarp just to west (Fig. 11)
14	Current meter	✓	
15	Other		

Weather, Ice, Surface Currents: Can have rough weather in southern winter

Territorial Jurisdiction: Australian

	Name/Address	Phone/FAX/Email
Contact Proponent:	Dr Neville Exon, Australian Geological Survey Organisation, PO Box 378, Canberra, Australia 2601	Ph: +61 6 2499347 Fax: + 61 6 2499980 Email: nexon@agso.gov.au

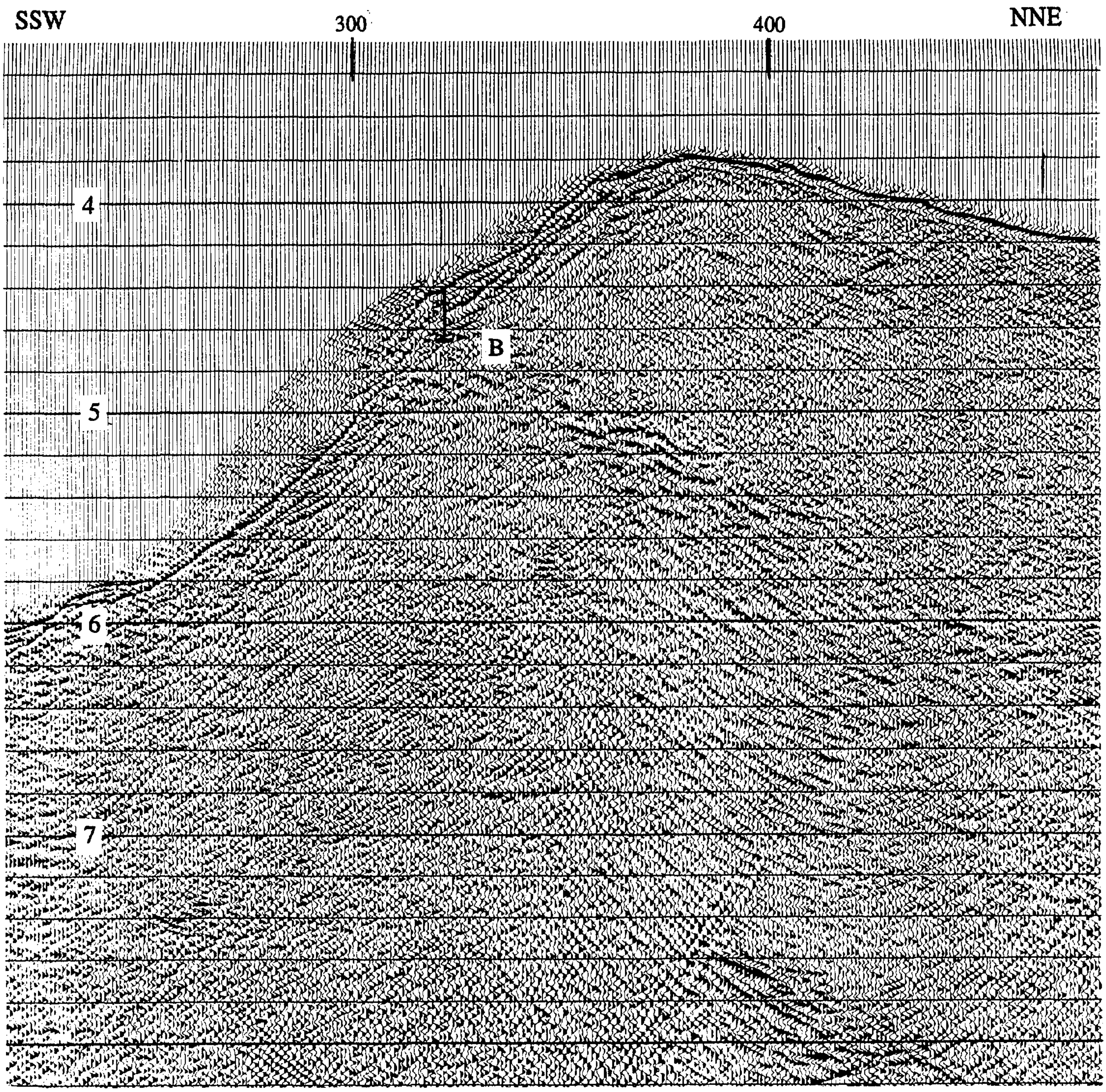


Figure 22. Location of proposed site TFZ02 on *Sonne* seismic profile SO36B-62.

ODP Site Summary Form6/93 Fill out one form for each proposed site and attach to proposal

Title of Proposal:	**The "southern gateway" between Australia and Antarctica: a proposal for ODP palaeoclimatic, palaeceanographic and tectonic drilling**
Site-specific Objective(s) (List of general objectives must be inc. in proposal)	A. Fully penetrate youngest Neogene pelagic carbonate sequence on STR (ca. 470 m) to give high-resolution biostratigraphy on the Indian Ocean side of the South Tasman Rise, for comparison with site further north (WT 1) that has not been influenced by movements of the Sub-Tropical Convergence, and further east on the Pacific Ocean side of the STR (SET 1 & ETP 1) B. Date age of Oligocene unconformity by penetrating underlying sequence. C. Fully penetrate Eocene to early Oligocene chalk (ca. 110 m) to give high-resolution biostratigraphy of the earliest fully marine sediments on the STR for comparison with calcareous sites further west and north (WT1, WSTR1) and on the Pacific Ocean side (ETP1).

	Proposed Site	Alternate Site
Site Name:	WSTR2	
Area:	west South Tasman Rise	
Lat./Long.:	47°08.5'S, 146°03'E	
Water Depth:	2730 m	
Sed. Thickness:	ca. 3000 m	
Total penetration:	580 m	

	Sediments	Basement
Penetration:	580 m	0 m
Lithology(ies):	0-470 m = Neogene ooze and chalk 470-580 m = late Eocene to early Oligocene chalk	
Coring (check):	1-2-3-APC ✓ VPC* XCB ✓ MDCB* PCS RCB ✓ DCS* Re-entry	
Downhole measurements:		

*Systems currently under development

Target(s) :(see Appendix of Proposal Submission Guidelines6/93) A ✓ B ✓ C D E F G (check)ß

Site Survey Information (see Appendix of Proposal Submission Guidelines6/93 for details and requirements):

		Check	Details of data available and data still to be collected
01	SCS deep penetration	✓	
02	SCS High Resolution	✓	
03	MCS and velocity	✓	*l'Atalante* 6 channel, *Sonne* 24 channel
04	Seismic grid		Crossing tracks
05	Refraction		
06	3.5 or 12 kHz	✓	
07	Swath bathymetry	✓	Simrad EM12D swath-mapping by *l'Atalante*
08	H.-res side-looking sonar	✓	
09	Photography/video		
10	Heat flow		
11	Magnetics/gravity	✓	*l'Atalante, Sonne*
12	Coring	✓	Nearby (Fig. 11)
13	Rock sampling	✓	On scarp to west (Fig. 11)
14	Current meter	✓	
15	Other		

Weather, Ice, Surface Currents: Can have rough weather in southern winter

Territorial Jurisdiction: Australian

	Name/Address	Phone/FAX/Email
Contact Proponent:	Dr Neville Exon, Australian Geological Survey Organisation, PO Box 378, Canberra, Australia 2601	Ph: +61 6 2499347 Fax: + 61 6 2499980 Email: nexon@agso.gov.au

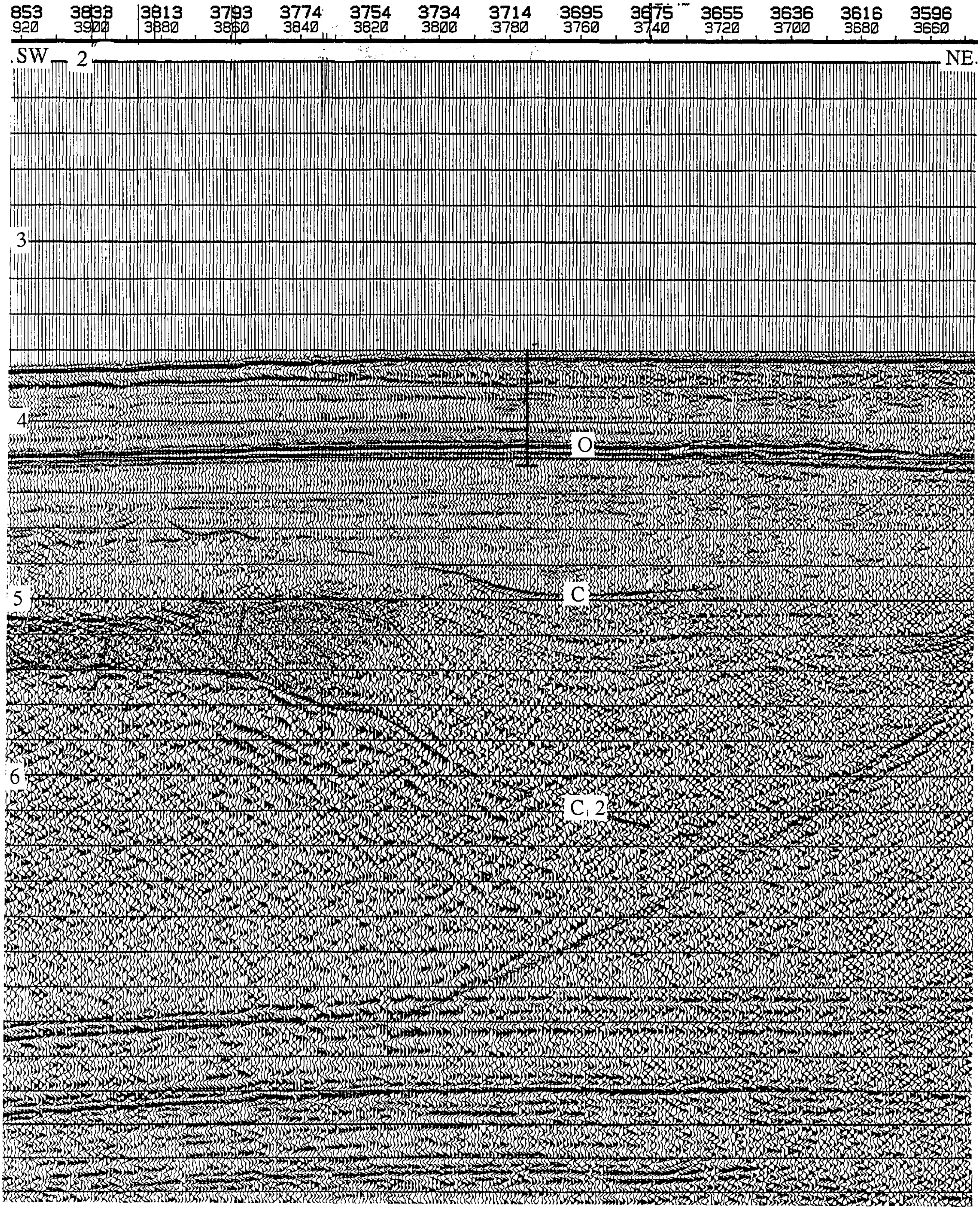


Figure 23. Location of proposed site WSTR2 on *Sonne* seismic profile SO36B-58; ties *Tasmante* seismic profile 14 at site.

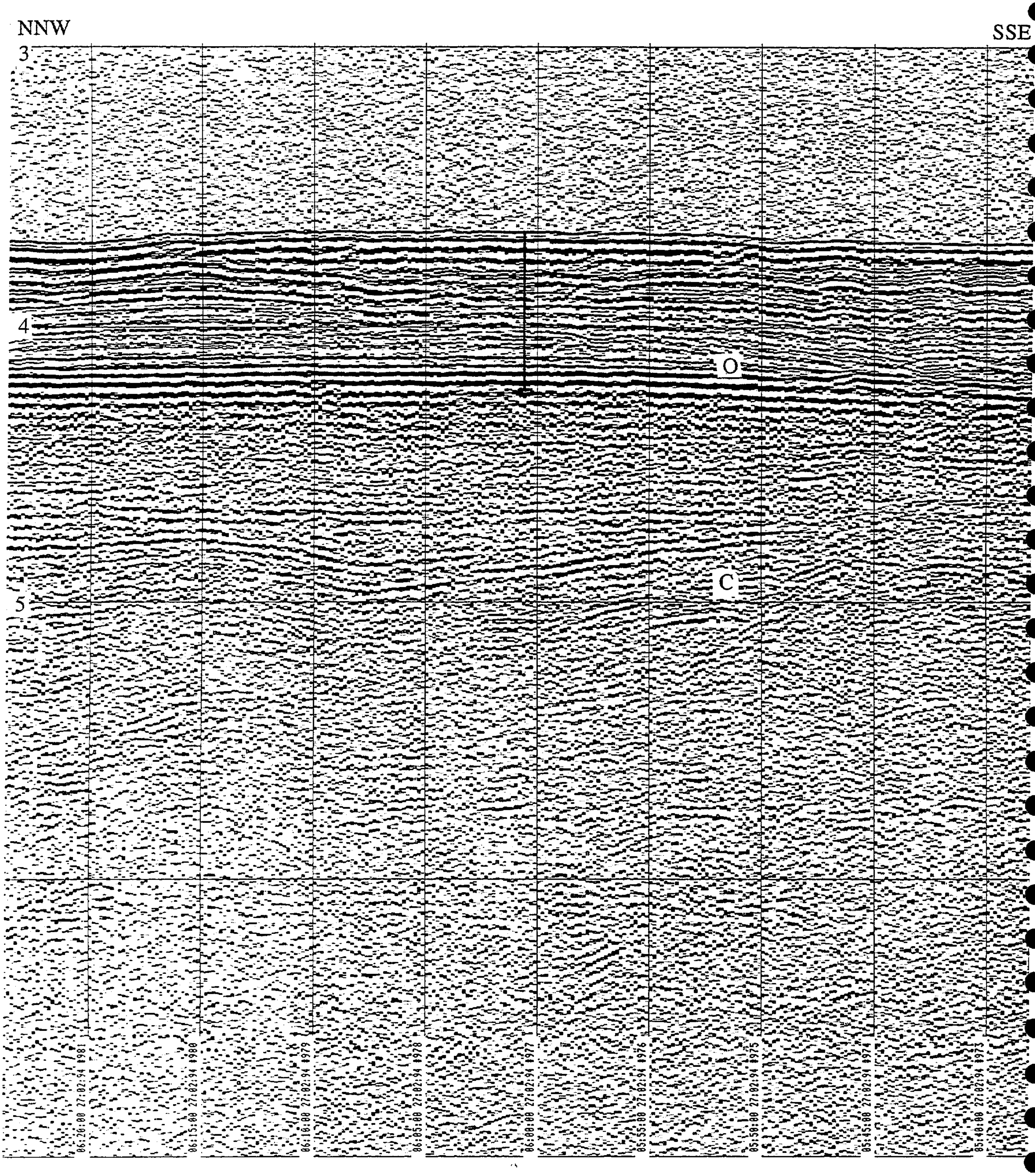


Figure 24. Location of proposed site WSTR2 on *Tasmante* seismic profile 14; ties *Sonne* seismic profile SO36B-58 at site.

ODP Site Summary Form6/93 Fill out one form for each proposed site and attach to proposal

Title of Proposal:	**The "southern gateway" between Australia and Antarctica: a proposal for ODP palaeoclimatic, palaeoceanographic and tectonic drilling**
Site-specific Objective(s) (List of general objectives must be inc. in proposal)	A. Fully penetrate siliceous Palaeogene marine mudstone (ca. 930 m) to give high-resolution biostratigraphy on the STR for comparison with calcareous sites further north on the Indian Ocean side (WT2, and east on the Pacific Ocean side (ETR1). B. By penetrating underlying Cretaceous sequence, date K/T unconformity and establish nature of Cretaceous deposition.

	Proposed Site	Alternate Site
Site Name:	STR1	
Area:	South of culmination of SouthTasman Rise	
Lat./Long.:	47°51'S, 147°52'E	
Water Depth:	1460 m	
Sed. Thickness:	2500 m	
Total penetration:	1160 m	

	Sediments	Basement
Penetration:	1160 m	0 m
Lithology(ies):	0-180 m = Neogene ooze; 180-1110 m = late Eocene mudstone; 50 m Cretaceous	
Coring (check):	1-2-3-APC✓ VPC* XCB✓ MDCB* PCS RCB✓ DCS* Re-entry✓	
Downhole measurements:		

*Systems currently under development

Target(s) :(see Appendix of Proposal Submission Guidelines6/93) A✓ B✓ C D E F G (check)ß

Site Survey Information (see Appendix of Proposal Submission Guidelines6/93 for details and requirements):

		Check	Details of data available and data still to be collected
01	SCS deep penetration	✓	
02	SCS High Resolution	✓	
03	MCS and velocity	✓	*l'Atalante* 6 channel, *Sonne* 24 channel
04	Seismic grid		Crossing tracks
05	Refraction		
06	3.5 or 12 kHz	✓	
07	Swath bathymetry	✓	Simrad EM12D swath-mapping by *l'Atalante*
08	H.-res side-looking sonar	✓	
09	Photography/video		
10	Heat flow		
11	Magnetics/gravity	✓	*l'Atalante, Sonne*
12	Coring	✓	DSDP 281 is 15 km to southwest
13	Rock sampling	✓	On scarps nearby (Fig. 11)
14	Current meter	✓	
15	Other		

Weather, Ice, Surface Currents: Can have rough weather in southern winter

Territorial Jurisdiction: Australian

	Name/Address	Phone/FAX/Email
Contact Proponent:	Dr Neville Exon, Australian Geological Survey Organisation, PO Box 378, Canberra, Australia 2601	Ph: +61 6 2499347 Fax: + 61 6 2499980 Email: nexon@agso.gov.au

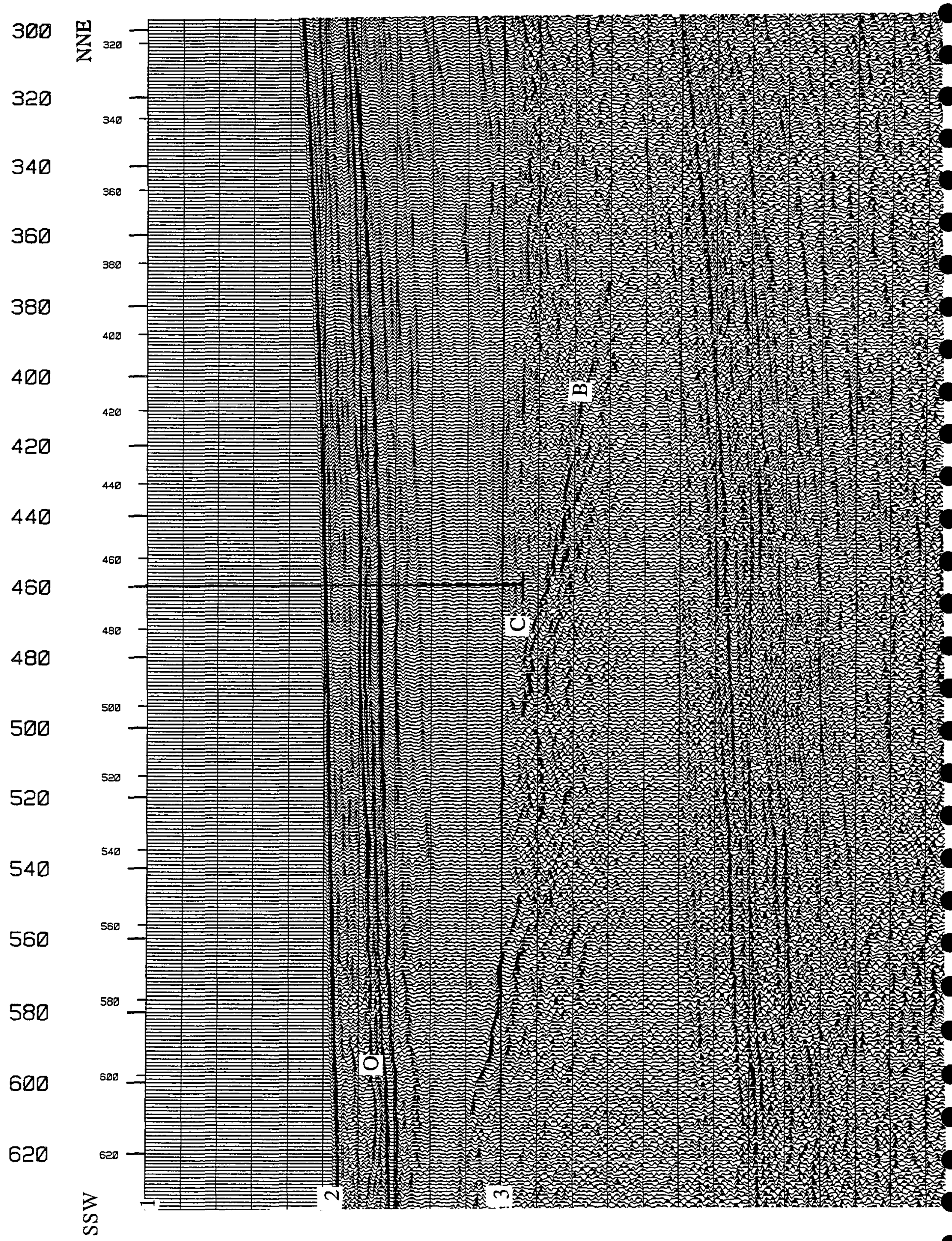


Figure 25. Location of proposed site STR1 on *Sonne* seismic profile SO36B-51; ties *Tasmante* seismic profile 31 at site.

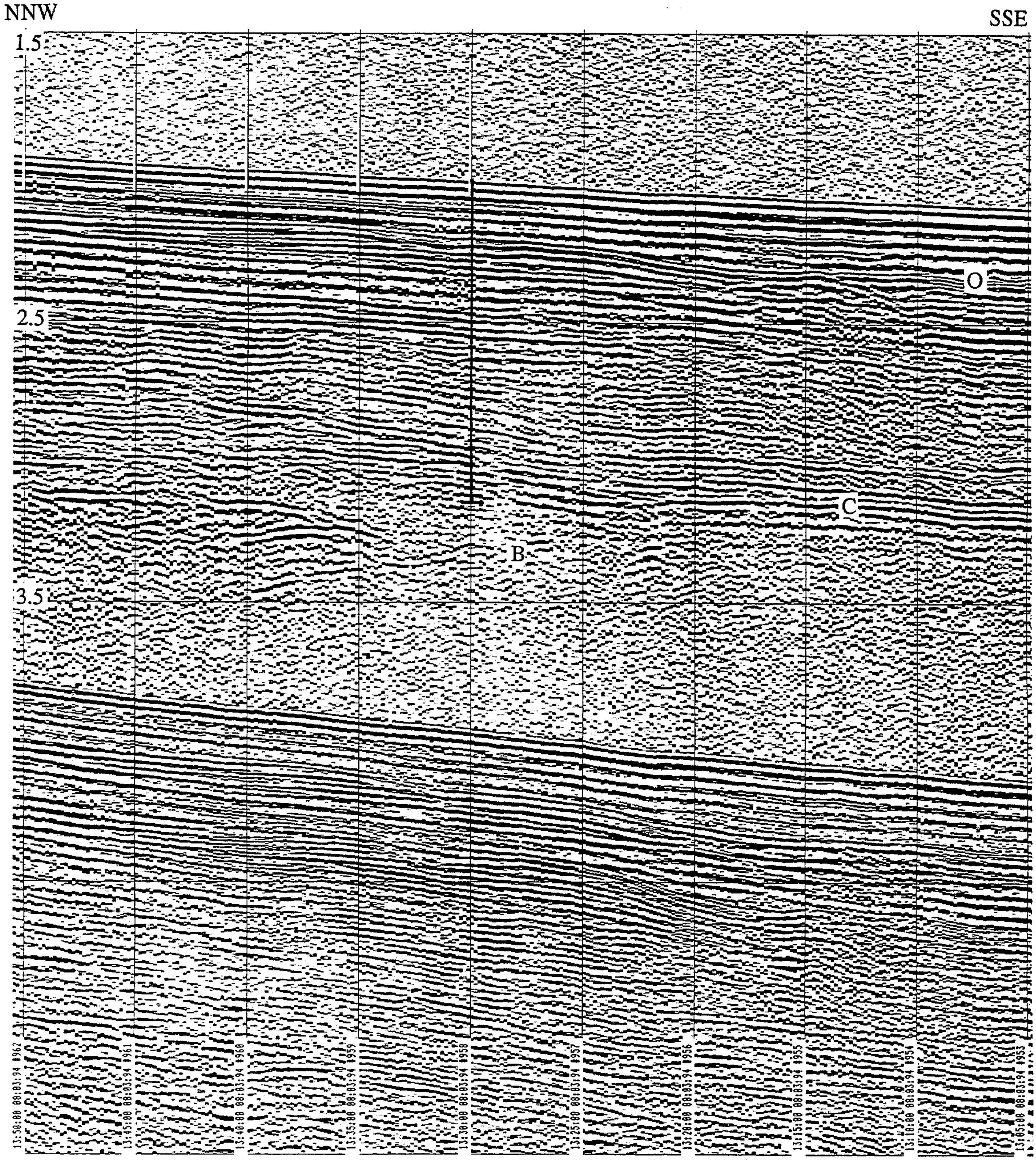


Figure 26. Location of proposed site STR1 on *Tasmante* seismic profile 31; ties *Sonne* seismic profile SO36B-51 at site.

ODP Site Summary Form6/93 Fill out one form for each proposed site and attach to proposal

Title of Proposal:	**The "southern gateway" between Australia and Antarctica: a proposal for ODP palaeoclimatic, palaeoceanographic and tectonic drilling**
Site-specific Objective(s) (List of general objectives must be inc. in proposal)	A. Fully penetrate Neogene pelagic carbonate drift sequence (ca. 500 m) to give high-resolution biostratigraphy on the Pacific Ocean side of the South Tasman Rise, for comparison with sites further south (STR 1 &WSTR 2) that have been influenced by movements of the Sub-Tropical Convergence) and further west on the Indian Ocean side of the STR (WT 1), and further north (ETP1) B. Date age of Oligocene unconformity by penetrating underlying sequence.

	Proposed Site	Alternate Site
Site Name:	SET1	
Area:	between STR and East Tasman Plateau	
Lat./Long.:	48°18.5'S, 147°55'E	
Water Depth:	4055 m	
Sed. Thickness:	1500-1700 m	
Total penetration:	500 m	

	Sediments	Basement
Penetration:	500 m	0 m
Lithology(ies):	0-400 m = Neogene ooze and chalk 400-500 m = late Eocene mudstone	
Coring (check):	1-2-3-APC✓ VPC* XCB✓ MDCB* PCS RCB✓ DCS* Re-entry	
Downhole measurements:		

*Systems currently under development

Target(s) :(see Appendix of Proposal Submission Guidelines6/93) A✓ B C D✓ E F G (check)ß

Site Survey Information (see Appendix of Proposal Submission Guidelines6/93 for details and requirements):

		Check	Details of data available and data still to be collected
01	SCS deep penetration	✓	
02	SCS High Resolution		
03	MCS and velocity	✓	*l'Atalante* 6 channel,
04	Seismic grid		No crossing track at this stage
05	Refraction		
06	3.5 or 12 kHz	✓	*l'Atalante*
07	Swath bathymetry	✓	Simrad EM12D swath-mapping by *l'Atalante*
08	H.-res side-looking sonar	✓	
09	Photography/video		
10	Heat flow		
11	Magnetics/gravity	✓	*l'Atalante*
12	Coring	✓	Nearby (Fig. 11)
13	Rock sampling	✓	On scarp to west (Fig. 11)
14	Current meter	✓	
15	Other		

Weather, Ice, Surface Currents: Can have rough weather in southern winter

Territorial Jurisdiction: Australian

	Name/Address	Phone/FAX/Email
Contact Proponent:	Dr Neville Exon, Australian Geological Survey Organisation, PO Box 378, Canberra, Australia 2601	Ph: +61 6 2499347 Fax: + 61 6 2499980 Email: nexon@agso.gov.au

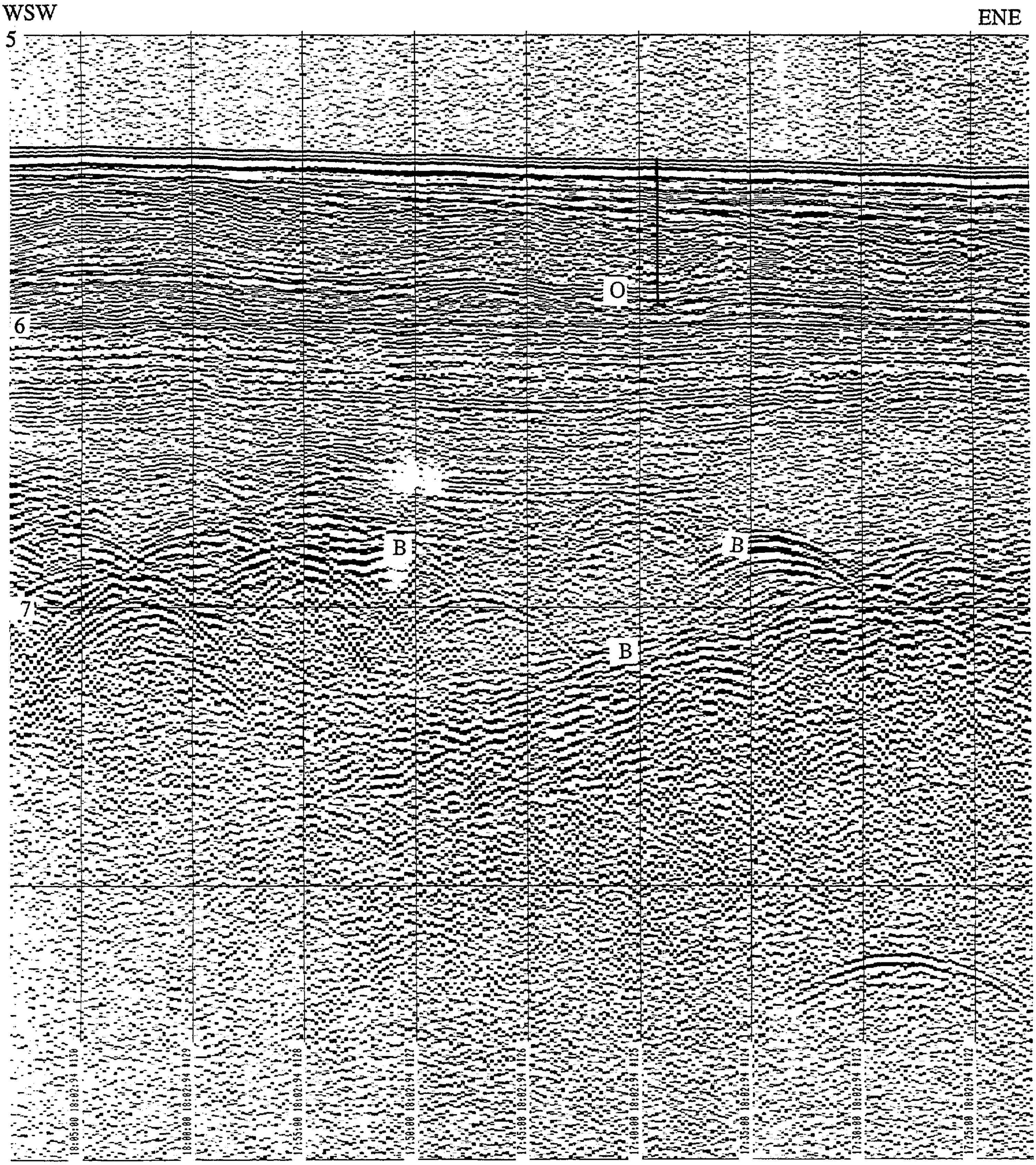


Figure 27. Location of proposed site SET1 on *Tasmante* seismic profile 4; no cross-tie at this time.

ODP Site Summary Form6/93 Fill out one form for each proposed site and attach to proposal

Title of Proposal:	**The "southern gateway" between Australia and Antarctica: a proposal for ODP palaeoclimatic, palaeceanographic and tectonic drilling**
Site-specific Objective(s) (List of general objectives must be inc. in proposal)	A. Fully penetrate Neogene pelagic carbonate sequence (ca. 380 m) to give high-resolution biostratigraphy on Pacific Ocean side of STR, for comparison with sites in other palaeogeographic positions (WT1, WSTR2) B. Date age of Oligocene unconformity by penetrating underlying sequence C. Fully penetrate siliceous Eocene to early Oligocene chalk (ca. 750 m) to give high-resolution biostratigraphy of the earliest fully marine sediments on the ETP for comparison with calcareous sites on the Indian Ocean side (WT1, WSTR1 & 2).

	Proposed Site	Alternate Site
Site Name:	ETP1	
Area:	East Tasman Plateau	
Lat./Long.:	43°54.6'S, 150°54.6'E	
Water Depth:	2800 m	
Sed. Thickness:	1105 m	
Total penetration:	615 m	

	Sediments	Basement
Penetration:	615 m	
Lithology(ies):	0-365 m = Neogene ooze; 365-585 m = Eocene to early Oligocene chalk; 585-615 m = Eocene deltaic mudstone	
Coring (check):	1-2-3-APC ✓ VPC* XCB ✓ MDCB* PCS RCB ✓ DCS* Re-entry	
Downhole measurements:		

*Systems currently under development

Target(s) :(see Appendix of Proposal Submission Guidelines6/93) A ✓ B ✓ C D E F G (check)ß

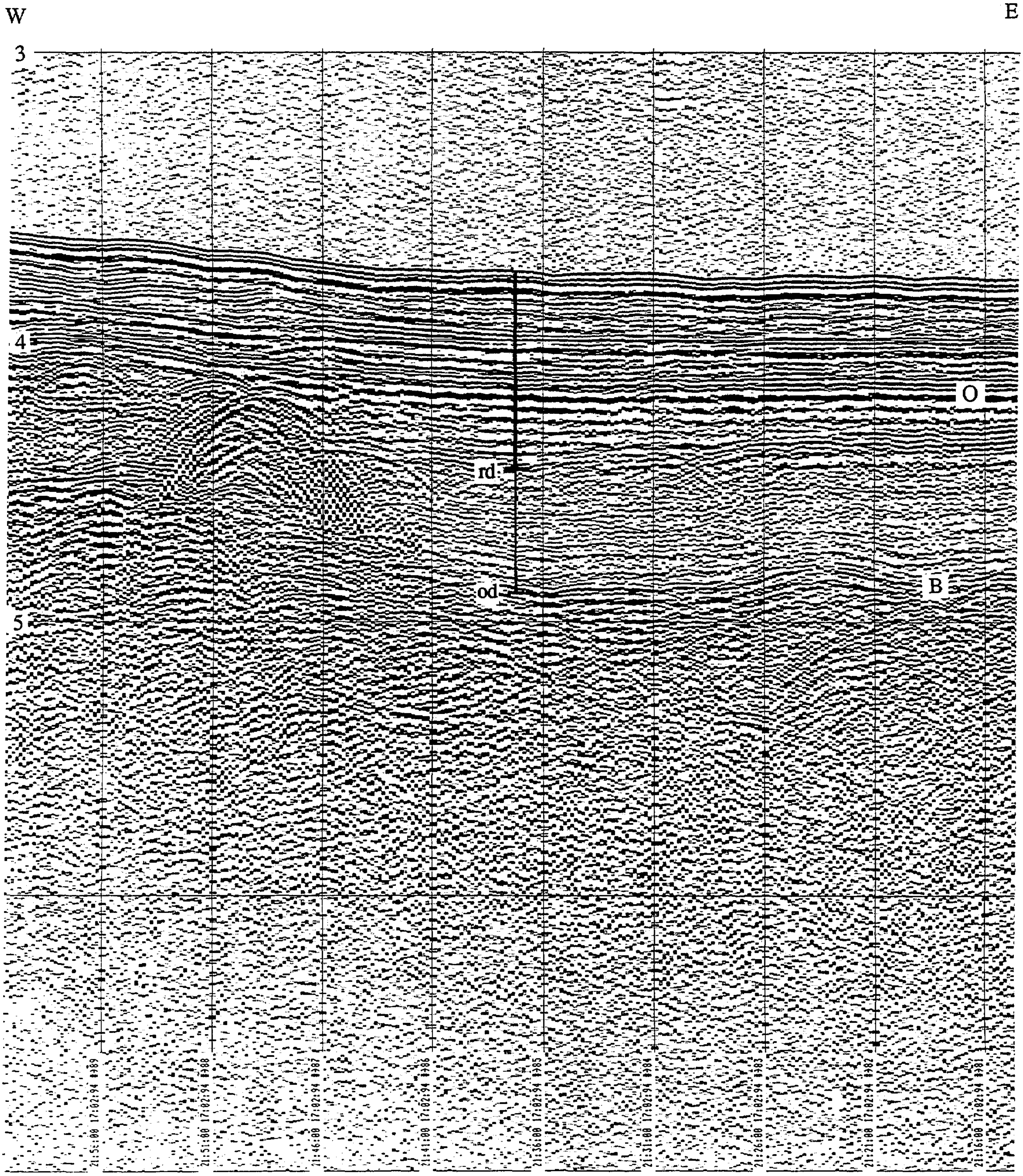
Site Survey Information (see Appendix of Proposal Submission Guidelines6/93 for details and requirements):

		Check	Details of data available and data still to be collected
01	SCS deep penetration	✓	
02	SCS High Resolution		
03	MCS and velocity	✓	*l'Atalante* 6 channel
04	Seismic grid		No crossing tracks at this stage
05	Refraction		
06	3.5 or 12 kHz	✓	
07	Swath bathymetry	✓	Simrad EM12D swath-mapping by *l'Atalante*
08	H.-res side-looking sonar	✓	
09	Photography/video		
10	Heat flow		
11	Magnetics/gravity	✓	*l'Atalante, Sonne*
12	Coring	✓	To west (Fig. 11)
13	Rock sampling	✓	On scarp to east (Fig. 11)
14	Current meter	✓	
15	Other		

Weather, Ice, Surface Currents: Can have rough weather in southern winter

Territorial Jurisdiction: Australian

	Name/Address	Phone/FAX/Email
Contact Proponent:	Dr Neville Exon, Australian Geological Survey Organisation, PO Box 378, Canberra, Australia 2601	Ph: +61 6 2499347 Fax: + 61 6 2499980 Email: nexon@agso.gov.au



od = optimal depth   rd = revised depth

Figure 28. Location of proposed site ETP1 on *Tasmante* seismic profile 3; no cross-tie at this time.